

Week 17

AP Environmental Science

Homework bundle for this week

本周作业合集

exercises.lol

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AP Environmental Science

Name: _____ Score: _____

1. A **renewable** resource is one that...
 - ☐ nature replaces as fast as we use it
 - ☐ runs out and cannot be replaced
 - ☐ is always cheap
 - ☐ is always dirty
2. Most of the world's energy today comes from...
 - ☐ fossil fuels
 - ☐ solar panels
 - ☐ wind turbines
 - ☐ geothermal
3. Which fuel powers most cars?
 - ☐ Gasoline (petrol), made from oil
 - ☐ Coal
 - ☐ Uranium
 - ☐ Firewood
4. Energy resources around the world are...
 - ☐ spread unevenly - some places have lots, others little
 - ☐ shared equally by every country
 - ☐ all found in one country
 - ☐ the same everywhere
5. Fossil fuels formed from...
 - ☐ the buried remains of ancient living things
 - ☐ melted rock from volcanoes
 - ☐ ocean salt
 - ☐ falling meteorites
6. Coal, oil, and natural gas are the three _____ fuels.

7. As populations and economies grow, total world energy demand is _____ (rising / falling).

8. Many homes burn natural _____ to heat rooms and cook food.

9. Because resources are unevenly spread, countries _____ energy with each other (buy and sell).

10. Burning fossil fuels releases carbon _____, the main greenhouse gas.

1. **nature replaces as fast as we use it**

A **renewable** resource is refilled by nature on a human timescale — sunlight, wind, and flowing water keep coming.

2. **fossil fuels**

Coal, oil, and natural gas together supply about 80% of world energy. Renewables are growing but still a smaller share.

3. **Gasoline (petrol), made from oil**

Gasoline, refined from oil, is the main transport fuel. Coal and uranium make electricity, not car fuel.

4. **spread unevenly - some places have lots, others little**

Nature places resources unevenly — a country may be rich in oil but have little sunshine, or the reverse.

5. **the buried remains of ancient living things**

Fossil fuels are the remains of plants and plankton, cooked by heat and pressure over millions of years.

6. **fossil**

Fossil fuels formed from ancient buried life; they are nonrenewable.

7. **rising**

More people and richer lifestyles push global energy demand steadily upward.

8. **gas**

Natural gas is a common heating and cooking fuel, and also generates electricity.

9. **trade**

Uneven distribution drives global energy **trade** — oil-rich nations sell to sun-poor, oil-poor ones.

10. **dioxide**

Combustion releases **carbon dioxide** (CO₂), which traps heat and warms the climate.

6.1 Renewable and Nonrenewable Resources

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS renewable 可再生 • nonrenewable 不可再生 • biomass 生物质 • wind 风能 • solar 太阳能

Objective

Build the skills to answer exam questions on **renewable and nonrenewable energy resources**.

You must be able to:

- classify energy sources as **renewable** 可再生 or **nonrenewable** 不可再生
- give examples of each
- explain the difference in supply

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Renewable vs nonrenewable

- **Renewable** energy is replenished naturally on a human timescale: solar, wind, hydro, geothermal, biomass.
- **Nonrenewable** energy is finite, formed over millions of years: coal, oil, natural gas, and nuclear (uranium).

■ Why the difference matters

Nonrenewable sources will eventually **run out** and cannot be replaced quickly; renewable sources can supply energy indefinitely if managed well.

■ A worked classification

Sunlight and wind are **renewable**; coal and uranium are **nonrenewable** (uranium is renewable... no — it is a finite mined element, so nonrenewable).

■ Note on biomass

Biomass (wood, crops) is **renewable** if replanted as fast as it is used, but can be unsustainable if harvested too fast.

2 Practice

Now apply the methods above.

2.1 Classify solar energy. [1]

2.2 Classify coal. [1]

2.3 Name two renewable energy sources. [2]

3 Exam-style questions

3.1 Which is a nonrenewable energy source? [1]

- **A** wind
 - **B** solar
 - **C** natural gas
 - **D** geothermal
-

3.2 A country relies mostly on coal and oil.

(a) Classify these sources. [1]

(b) Explain why this reliance is a long-term problem. [2]

3.3 Explain why biomass can be either renewable or unsustainable, depending on use. [2]

Solutions

2.1 Renewable.

2.2 Nonrenewable.

2.3 Any two: solar, wind, hydro, geothermal, biomass.

3.1 C — natural gas.

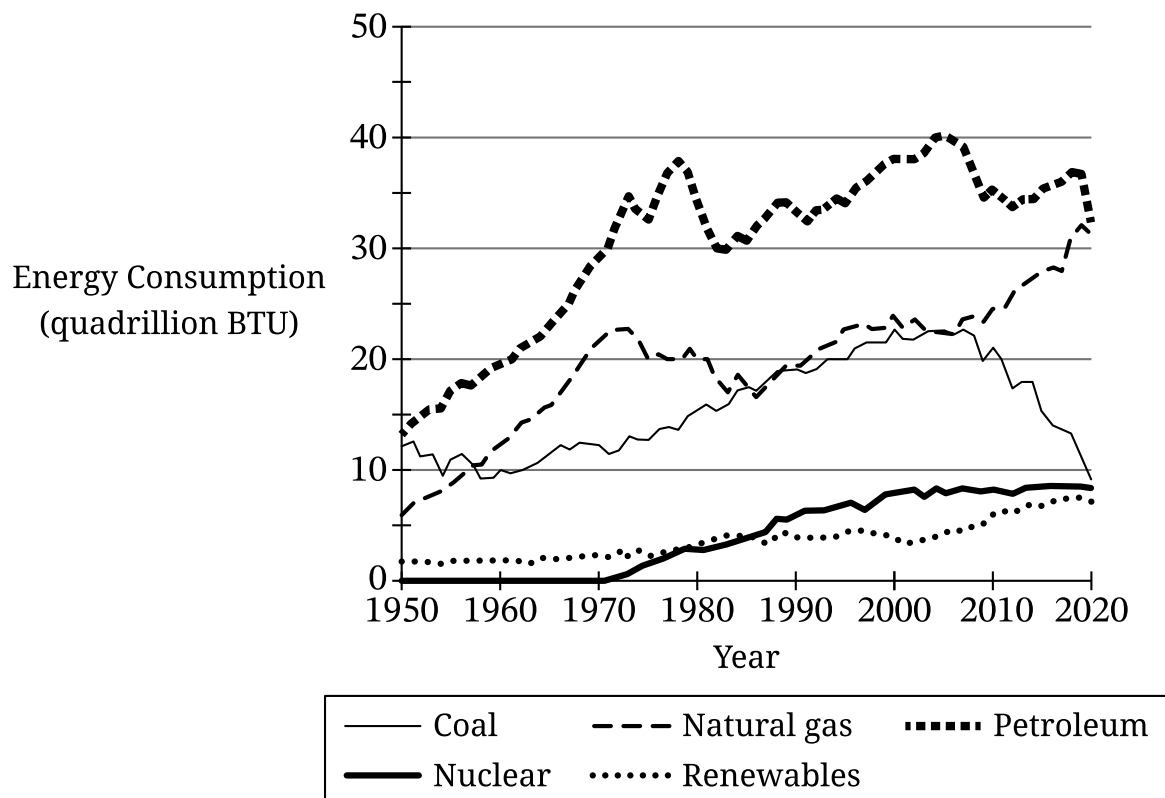
3.2 (a) Nonrenewable. (b) These finite sources will eventually run out and cannot be replaced on a human timescale, so the energy supply is not secure long-term.

3.3 If trees/crops are replanted as fast as they are burned, biomass is renewable; if harvested faster than they regrow, it is depleted and unsustainable.

The following information applies to parts A, B, C, D, E, F, and G.

The following graph shows the number of quadrillion British thermal units (BTUs) that were consumed in the United States using five different energy sources from 1950 to 2020.

Energy Consumption by Source in the United States, 1950–2020



The following information applies to parts H and I.

Researchers studied an aquatic ecosystem near an area of land that had been converted to agricultural use. They reported an increase in nutrients, such as nitrates and phosphates, in the water.

2. Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

Part A

Identify one renewable energy source that is used to generate electricity.

Part B

Based on the data in the graph, **identify** the energy source that had the highest consumption in 2010.

Part C

Based on the data in the graph, **describe** the pattern in the energy consumption from coal in the United States from 1960 to 2020.

Part D

Based on the data in the graph and your knowledge of energy consumption, **explain** one likely reason why the use of coal for energy changed between 2010 and 2020.

Part E

Explain how fossil fuels are used to generate electricity.

Part F

In addition to fossil fuels, nuclear power can be used to generate electricity. **Identify** one negative impact associated with nuclear energy.

Part G

Fossil fuel combustion leads to ocean warming. **Describe** one environmental problem other than coral bleaching that is associated with warming oceans.

Part H

Explain how an increase in nutrients, such as nitrates and phosphates, can negatively affect an aquatic ecosystem.

Part I

- i. **Propose** a realistic solution that would reduce nutrient pollution of waterways, while still allowing cultivation of crops.
- ii. **Justify** the solution proposed in part I (i) by explaining one potential advantage other than reducing nutrient runoff.

The local government of a newly built town has contracted with an electrical company to provide energy to the town. The company generates electricity primarily through the burning of coal and has built a new power plant for the town. A nearby deposit of coal was discovered close to the surface. To access the coal, the company decides to remove the overburden and vegetation over the deposit.

3. Respond to parts A, B, C, D, E, F, and G.

A. **Identify** a type of surface mining the company could use to access the coal.

B. **Describe** an environmental problem associated with surface mining.

C. The town is located downwind of the new coal-burning power plant.

Describe an environmental problem the town could experience as a result of the electricity generation at the coal-burning power plant.

D. The local government is concerned about the environmental consequences of using coal to generate electricity for the town.

Propose a realistic solution the local government could enact that would reduce the negative environmental consequences of using coal to generate electricity.

E. Burning one pound of coal produces an average of 0.88 kilowatt-hours (kWh) of electricity. An average household in the United States uses 1.064×10^4 kWh of electricity each year.

Calculate how many pounds of coal would need to be burned to generate enough electricity to power a town with 11,000 houses for a year. **Show** your work.

F. Researchers are concerned about the impact of noise pollution on songbirds in a forest near the power plant. Since the power plant was installed, bird species richness has declined from 7.5 species per hectare to 6.0 species per hectare.

Calculate the percent change in bird species per hectare since the power plant was installed. **Show** your work.

G. The town has been growing since it was built and had a growth rate of 5.38% in 2022, with a population of 26,250.

Assuming that the growth rate remains constant, **calculate** the year in which the population will reach 52,500. **Show** your work.

STOP

END OF EXAM

3. Approximately 350 coal-fired power plants in the United States are older than the 30-year anticipated life-span for a coal generator. One problem with these aging power plants is that many lack the necessary modern air pollution controls. Additionally, there are concerns about rising fuel costs, so many utility companies are planning to retire coal-fired plants and build new natural-gas power plants.

- (a) **Describe** why coal is considered a nonrenewable energy source.
- (b) **Describe** one potential environmental advantage of replacing a coal-fired power plant with a natural-gas power plant.
- (c) **Describe** one economic advantage of using natural gas, rather than coal, in producing electricity.
- (d) When natural gas is used to heat homes, it can produce carbon monoxide gas, which can lead to carbon monoxide poisoning in humans. **Propose** a solution to reduce the incidence of carbon monoxide poisoning in humans.

Particulate matter is another common pollutant in emissions from vehicles, coal-fired power plants, and various other sources. One size of particulates, $\text{PM}_{2.5}$, presents a particular risk to human health.

ATMOSPHERIC CONCENTRATION OF PARTICULATE MATTER IN 1990 AND 2016

Year	Average Annual Atmospheric Concentration of $\text{PM}_{2.5}$ ($\mu\text{g}/\text{m}^3$)
1990	85
2016	188

- (e) **Calculate** the percent change in the average annual $\text{PM}_{2.5}$ concentration in the air from 1990 to 2016. **Show** your work.
- (f) Trees can remove $\text{PM}_{2.5}$ from the atmosphere when particulates settle on the leaves and are subsequently washed onto soil by rain. The average annual removal of $\text{PM}_{2.5}$ is 2.3 kilograms per hectare. **Calculate** the decrease in $\text{PM}_{2.5}$ removal in kilograms if logging reduced a forested area from 50,000 hectares to 43,000 hectares. **Show** your work.
- (g) Research has shown that hospital admissions for cardiovascular problems increase 1% with every 10% increase in $\text{PM}_{2.5}$ concentration. A city experienced a 23% increase in $\text{PM}_{2.5}$ concentration and had 7,390 hospital admissions for cardiovascular issues over a one-year period. **Calculate** the anticipated increase in the number of hospital admissions for cardiovascular issues during the next year if the $\text{PM}_{2.5}$ concentration continues to rise at an identical rate. **Show** your work.

Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.

STOP

END OF EXAM

ENVIRONMENTAL SCIENCE**SECTION II****Time—1 hour and 30 minutes****4 Questions**

Directions: Answer all four questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers on the pages following the questions in this book. Where calculations are required, clearly show how you arrived at your answer. Where explanation or discussion is required, support your answers with relevant information and/or specific examples.

1. Read the following article from the *Fremont Daily Times* and answer the questions that follow.

Fremont Daily Times**May 1, 2018****GREEN IS THE NEW SCHOOL COLOR AT FREMONT HIGH SCHOOL!**

A group of students from Fremont High School addressed the city council last night and proposed that one of the existing buildings at Fremont High School, which was built in 1970, be renovated to take advantage of recent advances in green technology. Currently the heat for the school is provided by fossil fuel combustion. The students said that the redesigned building would reduce the school's carbon footprint, which is a measure of the amount of carbon dioxide and other carbon compounds released by various human activities. Incorporating specific features that conserve energy and utilize

renewable energy sources can help reduce the carbon footprint.

Councilperson Gail Fassler praised the idea, saying that the project could conserve local water resources, reduce the need for consuming new resources, and act as a “shining beacon” of sustainability for the greater Fremont community. Fassler suggested the project could even incorporate a living green roof as an additional sustainable feature. The council approved the initial site planning request and urged students to report back when the project was under way.

- (a) The students want to reduce the school's carbon footprint.
- (i) **Define** carbon footprint.
 - (ii) **Identify** one way the school's heating system is likely adding to the school's carbon footprint.
 - (iii) **Describe** one realistic way to reduce the contribution of the heating system to the school's carbon footprint.
- (b) **Identify** TWO environmental benefits of a living green roof, such as that suggested by Councilperson Fassler.
- (c) **Describe** TWO practices the cafeteria's food service could use to decrease the environmental impacts of Fremont High School.
- (d) **Discuss** TWO benefits of using native plants for landscaping at Fremont High School.
- (e) During the renovation, the carpeting must be replaced. **Discuss** one environmental benefit of using flooring made of plant material, such as cork or bamboo, instead of carpet made of synthetic fibers.

2. Iron ores are rocks from which metallic iron can be extracted for steel production. This process involves several steps. Iron ore is first mined and then turned into pig iron in a blast furnace, and some rock waste such as silicon dioxide is separated out. In the final step, the pig iron is refined into steel using a process that includes reacting the molten pig iron with oxygen to remove impurities.

(a) Use the data below to respond to the following. For each calculation, show all your work.

Global Iron and Steel Data
1.6 billion tons of iron ore are used yearly to make pig iron.
1.2 billion tons of pig iron are produced each year.
Iron ore reserves are estimated to be 800 billion tons.
95% of iron ore that is mined is used in steel production.

- (i) **Calculate** the weight (in tons) of rock waste produced globally each year when iron ore is converted to pig iron.
- (ii) **Calculate** the weight (in tons) of pig iron that could be produced if all of the estimated global iron ore reserves were used for pig iron production.
- (iii) **Calculate** the weight (in tons) of the current global iron ore reserves that would be used to make steel if the current trends continue.

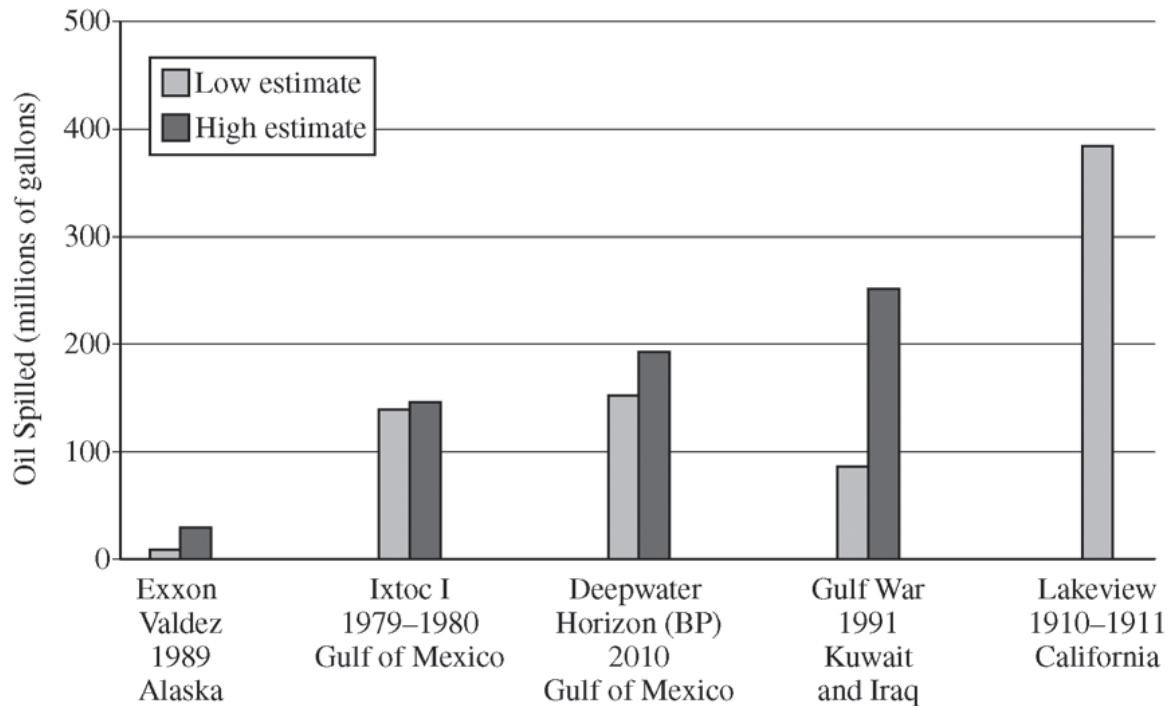
Both iron ore and coal are mined for use in the manufacture of steel. It is estimated that for every ton of steel recycled, 1.25 fewer tons of iron ore and 0.7 fewer tons of coal must be mined. About 80 million tons of steel are recycled each year in North America.

- (b) **Calculate** the weight (in tons) of coal that is conserved each year in North America by recycling steel.

Before the year 1900, most mining companies abandoned surface and subsurface coal mine sites once the resource was depleted.

- (c) **Describe** TWO environmental problems that are associated with abandoned coal mine sites.
- (d) **Describe** one method that can be used to mitigate one of the problems you identified in part (c).
- (e) **Discuss** one reason why surface coal mining is generally less expensive than subsurface mining.

VOLUME OF OIL RELEASED IN SELECTED INCIDENTS



3. Oil spills can be devastating in scope and damage. Since 1900, there have been many oil spills around the world that have had significant ecological and economic impacts.
- (a) Using the data in the graph above, **determine** the maximum volume of oil estimated to have been spilled during the Deepwater Horizon (BP) incident.
 - (b) **Describe** TWO environmental problems that can result from oil spills in coastal areas.
 - (c) **Identify** one economic impact that results from oil spills in coastal areas.
 - (d) Chemical dispersants have been used in cleanup efforts following major oil spills.
 - (i) **Discuss** both one advantage and one disadvantage of the use of chemical dispersants for oil spill cleanup.
 - (ii) **Identify** either one biological or one physical method (other than chemical dispersal) used for oil spill cleanup in coastal waters or on beaches and **describe** how the method is used.
 - (e) Catastrophic spills make up less than 20 percent of the oil that pollutes marine waters. **Identify** one other source of oil contamination and **explain** how the oil from this source enters marine waters.
 - (f) Petroleum has many uses as a raw material for consumer goods. **Identify** one substitute for petroleum in a specific consumer product (other than fuel).

6.2 Global Energy Consumption

Name: _____ Class: _____ Date: _____

Total: 9 marks

KEY WORDS fossil fuels 化石燃料

Objective

Build the skills to answer exam questions on **global energy consumption**.

You must be able to:

- describe patterns of energy use across **developed** and **developing** countries
- explain why consumption is rising
- link consumption to development

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Global patterns

Developed countries use far more energy **per person** than developing ones. As **developing** countries industrialize and grow, their total energy use rises rapidly.

■ Fossil fuels dominate

Most of the world's energy still comes from **fossil fuels** (oil, coal, natural gas), though renewables are growing.

■ Why consumption rises

Rising **population**, **industrialization**, and **living standards** all increase energy demand — more machines, transport, and appliances.

■ A worked comparison

A person in a wealthy industrialized country typically uses many times more energy than a person in a low-income country, mainly for transport, heating/cooling, and manufactured goods.

2 Practice

Now apply the methods above.

2.1 Which use more energy per person: developed or developing countries? [1]

2.2 What is the world's dominant energy source? [1]

2.3 State one reason global energy use is rising. [1]

3 Exam-style questions

3.1 Global energy consumption is rising mainly due to [1]

- **A** falling population
 - **B** industrialization and rising living standards
 - **C** less transport
 - **D** fewer appliances
-

3.2 A developing country begins to industrialize rapidly.

(a) Predict what happens to its energy consumption. [1]

(b) Explain why. [2]

3.3 Explain why per-person energy use is higher in developed countries. [2]

Solutions

2.1 Developed countries.

2.2 Fossil fuels.

2.3 Any one: population growth, industrialization, rising living standards.

3.1 B — industrialization and rising living standards.

3.2 (a) It rises (increases). (b) Industrialization adds factories, transport, and appliances, and rising incomes increase demand, so energy use grows.

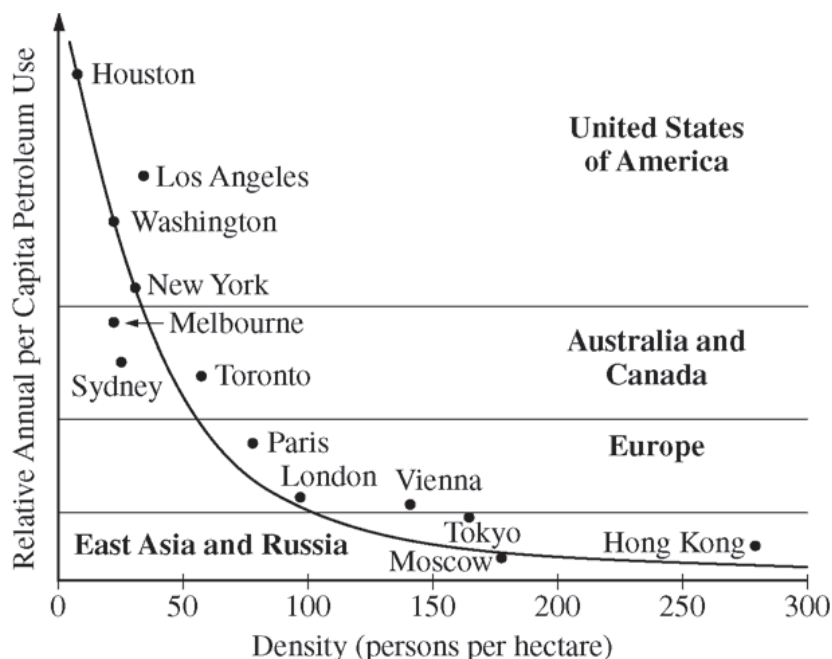
3.3 Developed countries have more industry, cars, heating/cooling, and manufactured goods per person, all of which require large amounts of energy.

2. An offshore wind farm project using turbines to generate electricity is to be built along the Atlantic coast of the United States. It will be located about 13 km from the coast in water with an average depth of 10 m.
- (a) **Describe** one environmental benefit associated with an offshore wind project.
 - (b) **Identify** and **describe** one potential economic effect of an offshore wind project.
 - (c) **Describe** one additional way, other than wind power, that oceans can provide renewable energy for the generation of electricity.

The project will consist of 200 wind turbines, each with a capacity of 4 megawatts (MW). Each turbine costs \$1.2 million to build. Electrical demand in the area to be served by the project is expected to be 2.0×10^6 MWh per year.

- (d) **Calculate** how much electricity (in MWh) the wind project needs to generate per year in order to provide 80% of the annual electrical demand in the service area. Show all work.
- (e) Customers in the service area pay \$0.20/kWh for electricity. **Calculate** how much revenue will be produced if the wind turbines provide 80% of the annual electrical demand in the service area. Show all work.
- (f) Assuming all turbines are operating, **calculate** how many hours the wind turbines must operate to provide 80% of the annual electrical demand in the service area. Show all work.

4. The term “urban sprawl” describes the expansion of cities into rural areas. This phenomenon has occurred around the world and has had economic, health, and environmental consequences.
- (a) **Describe** TWO causes of urban sprawl.
- (b) **Discuss** TWO human health effects associated with urban sprawl.
- (c) The graph below shows the relationship between population density and petroleum use in selected cities. **Describe** the relationship between population density and petroleum use shown in the graph.



- (d) Smart growth focuses on ways to encourage sustainable urban development. **Describe** TWO steps a municipality could take to encourage smart growth in order to limit urban sprawl.
- (e) Highway systems and urban sprawl often threaten wildlife populations. **Describe** TWO methods to reduce harmful effects on wildlife populations from highways and urban sprawl.
- (f) Urban sprawl often results in the loss of productive agricultural land near cities. **Describe** one practical way to increase food production within urban areas.

STOP

END OF EXAM

6.3 Fuel Types and Uses

Name: _____ Class: _____ Date: _____

Total: 11 marks

KEY WORDS biomass 生物质

Objective

Build the skills to answer exam questions on **fuel types and uses**.

You must be able to:

- match fuels (coal, oil, natural gas) to their main uses
- compare their energy content and pollution
- explain **fuelwood** use in developing regions

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Main fuels and uses

- **Coal** — mainly for **electricity** generation; high CO₂ and pollution.
- **Oil (petroleum)** — mainly **transportation** (gasoline, diesel).
- **Natural gas** — heating and electricity; **cleanest** fossil fuel (least CO₂ per energy).

■ Pollution ranking

For the same energy, **coal** pollutes most (most CO₂, sulfur), then oil, then **natural gas** (least). This is why gas is often a "bridge" fuel.

■ Fuelwood

In many **developing** regions, **fuelwood** and charcoal are the main energy source for cooking/heating, which can drive deforestation and indoor air pollution.

■ A worked match

A power plant burning coal produces electricity; a car burns gasoline (from oil) — different fuels for different main uses.

2 Practice

Now apply the methods above.

2.1 Which fossil fuel is mainly used for transportation? [1]

2.2 Which fossil fuel is the cleanest-burning? [1]

2.3 What is the main energy source in many developing regions? [1]

3 Exam-style questions

3.1 Coal is used mainly for [1]

- **A** transportation
 - **B** electricity generation
 - **C** cooking oil
 - **D** plastics only
-

3.2 Three power options: coal, natural gas, and oil.

(a) Rank them from most to least CO₂ per unit energy. [2]

(b) State the main use of each. [3]

3.3 Explain why heavy fuelwood use can harm the environment in developing regions.[2]

Solutions

2.1 Oil (petroleum).

2.2 Natural gas.

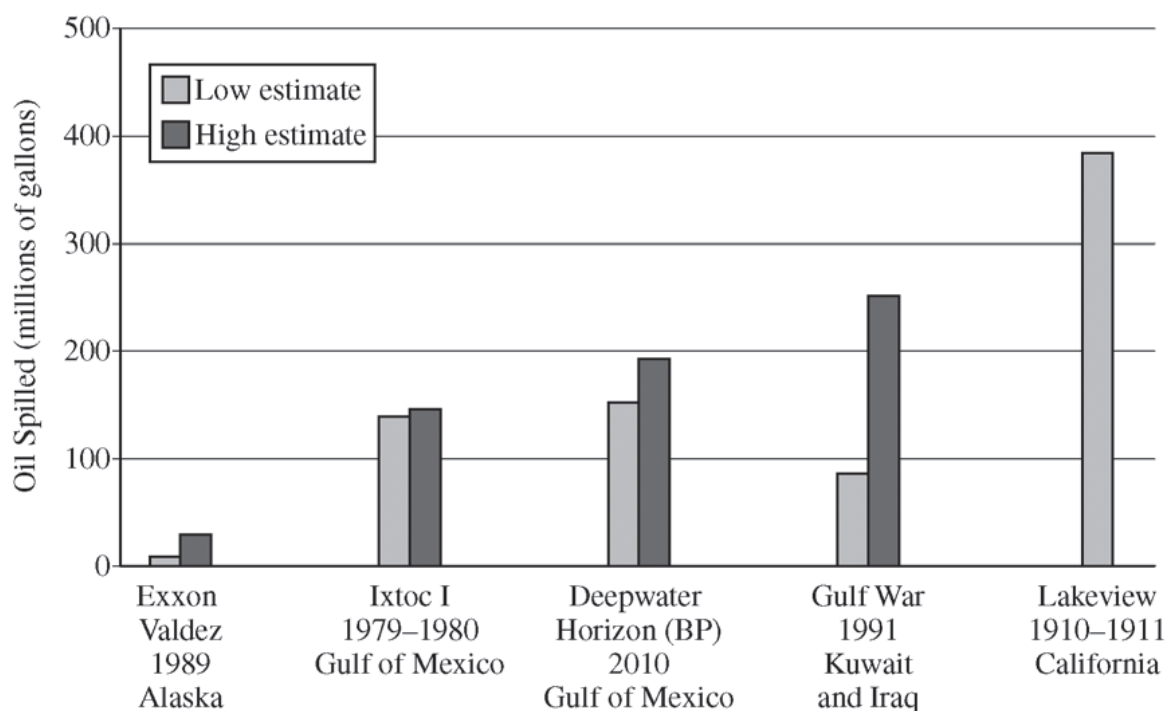
2.3 Fuelwood (or charcoal/biomass).

3.1 B — electricity generation.

3.2 (a) Coal > oil > natural gas. (b) Coal → electricity; oil → transportation; natural gas → heating/electricity.

3.3 Collecting fuelwood faster than it regrows causes deforestation (erosion, habitat loss), and burning it indoors causes indoor air pollution and health problems.

VOLUME OF OIL RELEASED IN SELECTED INCIDENTS



3. Oil spills can be devastating in scope and damage. Since 1900, there have been many oil spills around the world that have had significant ecological and economic impacts.
- (a) Using the data in the graph above, **determine** the maximum volume of oil estimated to have been spilled during the Deepwater Horizon (BP) incident.
 - (b) **Describe** TWO environmental problems that can result from oil spills in coastal areas.
 - (c) **Identify** one economic impact that results from oil spills in coastal areas.
 - (d) Chemical dispersants have been used in cleanup efforts following major oil spills.
 - (i) **Discuss** both one advantage and one disadvantage of the use of chemical dispersants for oil spill cleanup.
 - (ii) **Identify** either one biological or one physical method (other than chemical dispersal) used for oil spill cleanup in coastal waters or on beaches and **describe** how the method is used.
 - (e) Catastrophic spills make up less than 20 percent of the oil that pollutes marine waters. **Identify** one other source of oil contamination and **explain** how the oil from this source enters marine waters.
 - (f) Petroleum has many uses as a raw material for consumer goods. **Identify** one substitute for petroleum in a specific consumer product (other than fuel).

6.4 Distribution of Natural Energy Resources

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS unevenly distributed 分布不均 • wind 风能 • geothermal 地热能 • fossil fuels 化石燃料
• solar 太阳能

Objective

Build the skills to answer exam questions on the **distribution of natural energy resources**.

You must be able to:

- explain that energy resources are **unevenly distributed** 分布不均
- link distribution to geology and geography
- discuss the consequences for trade and security

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Uneven distribution

Energy resources are **unevenly spread** across the world because they depend on **geology and geography**:

- **Fossil fuels** form where ancient organic matter was buried (specific oil/coal regions).
- **Solar** is best in sunny low latitudes; **wind** where it is consistently windy; **geothermal** near plate boundaries; **hydro** where there are large rivers.

■ Consequences

Countries with few resources must **import** energy, affecting **trade**, prices, and **energy security**. Rich deposits can bring wealth but also conflict.

■ A worked link

A country near a tectonic boundary can use **geothermal** energy, while a flat, calm, cloudy country may rely on imports or other sources.

2 Practice

Now apply the methods above.

2.1 Why are energy resources unevenly distributed? [1]

2.2 Where is geothermal energy most available? [1]

2.3 What must a country with few energy resources often do? [1]

3 Exam-style questions

3.1 Solar power is most available in regions that are [1]

- **A** cloudy and dark
 - **B** sunny (often low latitude)
 - **C** near the poles only
 - **D** underground
-

3.2 A country has strong, steady coastal winds but no fossil fuels.

(a) Suggest a suitable energy source. [1]

(b) Explain how uneven resource distribution affects a country's energy choices and security. [3]

3.3 Explain why a nation near a plate boundary might develop geothermal energy. [2]

Solutions

2.1 They depend on geology and geography, which vary from place to place.

2.2 Near plate boundaries / volcanic regions.

2.3 Import energy.

3.1 B — sunny (often low latitude).

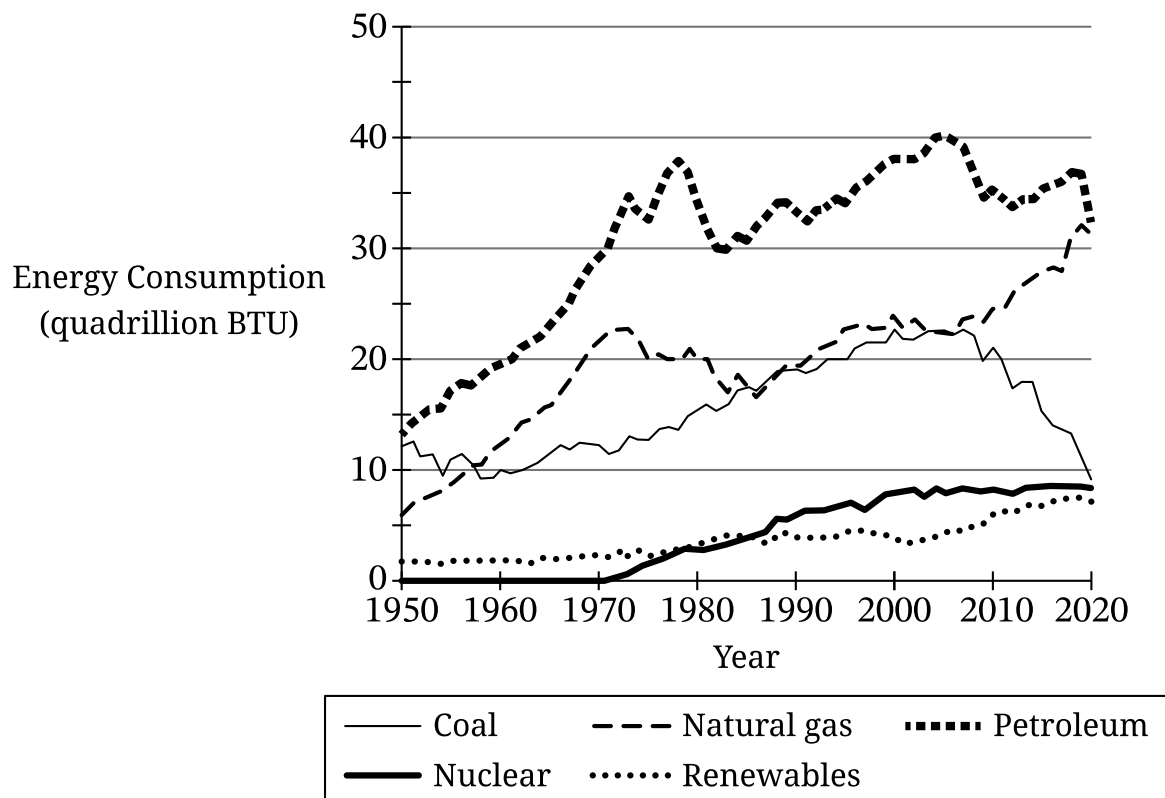
3.2 (a) Wind energy. (b) A country uses the resources its geography provides; those lacking resources must import, which affects trade, prices, and energy security (dependence on others).

3.3 Near a plate boundary, heat from the Earth is close to the surface, so geothermal energy can be tapped to generate power.

The following information applies to parts A, B, C, D, E, F, and G.

The following graph shows the number of quadrillion British thermal units (BTUs) that were consumed in the United States using five different energy sources from 1950 to 2020.

Energy Consumption by Source in the United States, 1950–2020



The following information applies to parts H and I.

Researchers studied an aquatic ecosystem near an area of land that had been converted to agricultural use. They reported an increase in nutrients, such as nitrates and phosphates, in the water.

2. Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

Part A

Identify one renewable energy source that is used to generate electricity.

Part B

Based on the data in the graph, **identify** the energy source that had the highest consumption in 2010.

Part C

Based on the data in the graph, **describe** the pattern in the energy consumption from coal in the United States from 1960 to 2020.

Part D

Based on the data in the graph and your knowledge of energy consumption, **explain** one likely reason why the use of coal for energy changed between 2010 and 2020.

Part E

Explain how fossil fuels are used to generate electricity.

Part F

In addition to fossil fuels, nuclear power can be used to generate electricity. **Identify** one negative impact associated with nuclear energy.

Part G

Fossil fuel combustion leads to ocean warming. **Describe** one environmental problem other than coral bleaching that is associated with warming oceans.

Part H

Explain how an increase in nutrients, such as nitrates and phosphates, can negatively affect an aquatic ecosystem.

Part I

- i. **Propose** a realistic solution that would reduce nutrient pollution of waterways, while still allowing cultivation of crops.
- ii. **Justify** the solution proposed in part I (i) by explaining one potential advantage other than reducing nutrient runoff.

2. As conventional sources of crude oil are depleted, unconventional sources such as oil sands (also known as tar sands) are being utilized. Oil sands contain bitumen, which can be processed into a synthetic crude oil. A region of boreal forest in Alberta, Canada, that covers a deposit of oil sands will be cut and removed during the process of bitumen extraction. It is estimated that the deposit contains 73 billion barrels of recoverable bitumen. The rate of extraction from the deposit will be approximately 1 million barrels of bitumen per day.
- (a) **Identify** one ecological benefit, other than providing habitat, that is provided by forests.
 - (b) **Identify** one economic benefit that is provided by forests.
 - (c) **Describe** TWO environmental consequences, other than those related to the loss of boreal forest habitat, that result from the extraction of bitumen or the transportation of synthetic oil to customers.
 - (d) Assuming the above extraction rate, **calculate** how many days will be needed to extract the recoverable volume of bitumen from the oil sands.
 - (e) **Calculate** how many years will be needed to fully extract the recoverable volume of bitumen from the oil sands.
 - (f) Monthly production of synthetic crude oil is 30 million barrels. Producing one barrel of synthetic crude oil uses two barrels of heated freshwater. **Calculate** the number of barrels of freshwater needed each year to supply this demand.

2. An offshore wind farm project using turbines to generate electricity is to be built along the Atlantic coast of the United States. It will be located about 13 km from the coast in water with an average depth of 10 m.
- (a) **Describe** one environmental benefit associated with an offshore wind project.
 - (b) **Identify** and **describe** one potential economic effect of an offshore wind project.
 - (c) **Describe** one additional way, other than wind power, that oceans can provide renewable energy for the generation of electricity.

The project will consist of 200 wind turbines, each with a capacity of 4 megawatts (MW). Each turbine costs \$1.2 million to build. Electrical demand in the area to be served by the project is expected to be 2.0×10^6 MWh per year.

- (d) **Calculate** how much electricity (in MWh) the wind project needs to generate per year in order to provide 80% of the annual electrical demand in the service area. Show all work.
- (e) Customers in the service area pay \$0.20/kWh for electricity. **Calculate** how much revenue will be produced if the wind turbines provide 80% of the annual electrical demand in the service area. Show all work.
- (f) Assuming all turbines are operating, **calculate** how many hours the wind turbines must operate to provide 80% of the annual electrical demand in the service area. Show all work.

6.5 Fossil Fuels

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS fossil fuels 化石燃料 • dam 大坝

Objective

Build the skills to answer exam questions on **fossil fuels**.

You must be able to:

- describe how **fossil fuels** 化石燃料 form and are used
- explain their environmental impacts (CO₂, pollution, extraction)
- state advantages and disadvantages

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Formation and use

Fossil fuels (coal, oil, natural gas) formed from ancient organisms buried and compressed over millions of years. They are burned to release energy — the world's main energy source.

■ Advantages

- **High energy density** (a lot of energy per unit).
- **Cheap** and reliable with existing infrastructure.

■ Disadvantages

- Burning releases **CO₂** (climate change) and pollutants (SO₂, particulates → acid rain, smog).
- **Extraction** damages land and water (mining, oil spills, fracking).
- **Nonrenewable** — will run out.

■ A worked judgement

Coal is cheap and energy-dense but produces the most CO₂ and air pollution of the fossil fuels, so it has the greatest climate impact.

2 Practice

Now apply the methods above.

2.1 How do fossil fuels form? [1]

2.2 State one advantage of fossil fuels. [1]

2.3 State one environmental disadvantage. [1]

3 Exam-style questions

3.1 Burning fossil fuels contributes to climate change mainly by releasing [1]

- **A** oxygen
 - **B** carbon dioxide
 - **C** water only
 - **D** nitrogen gas
-

3.2 A country generates most of its electricity from coal.

(a) State two environmental impacts. [2]

(b) Explain one reason it still relies on coal despite these impacts. [2]

3.3 Explain why fossil fuels are described as a finite resource. [2]

Solutions

2.1 From ancient organisms buried and compressed over millions of years.

2.2 Any one: high energy density, cheap, reliable, existing infrastructure.

2.3 Any one: CO₂/climate change, air pollution, extraction damage.

3.1 B — carbon dioxide.

3.2 (a) Any two: CO₂ emissions, air pollution/acid rain, land/water damage from mining.

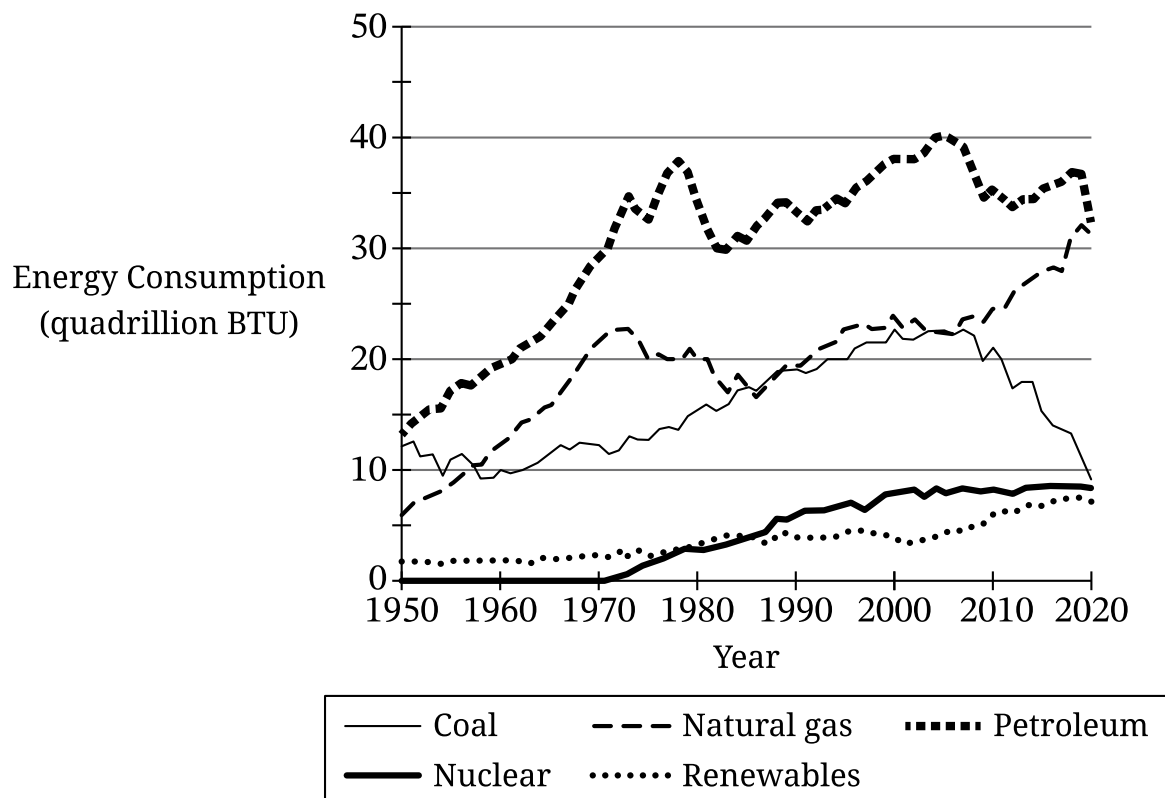
(b) It is cheap, energy-dense, reliable, and the infrastructure already exists.

3.3 They form over millions of years — far slower than we use them — so the supply is limited and cannot be replaced on a human timescale.

The following information applies to parts A, B, C, D, E, F, and G.

The following graph shows the number of quadrillion British thermal units (BTUs) that were consumed in the United States using five different energy sources from 1950 to 2020.

Energy Consumption by Source in the United States, 1950–2020



The following information applies to parts H and I.

Researchers studied an aquatic ecosystem near an area of land that had been converted to agricultural use. They reported an increase in nutrients, such as nitrates and phosphates, in the water.

2. Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

Part A

Identify one renewable energy source that is used to generate electricity.

Part B

Based on the data in the graph, **identify** the energy source that had the highest consumption in 2010.

Part C

Based on the data in the graph, **describe** the pattern in the energy consumption from coal in the United States from 1960 to 2020.

Part D

Based on the data in the graph and your knowledge of energy consumption, **explain** one likely reason why the use of coal for energy changed between 2010 and 2020.

Part E

Explain how fossil fuels are used to generate electricity.

Part F

In addition to fossil fuels, nuclear power can be used to generate electricity. **Identify** one negative impact associated with nuclear energy.

Part G

Fossil fuel combustion leads to ocean warming. **Describe** one environmental problem other than coral bleaching that is associated with warming oceans.

Part H

Explain how an increase in nutrients, such as nitrates and phosphates, can negatively affect an aquatic ecosystem.

Part I

- i. **Propose** a realistic solution that would reduce nutrient pollution of waterways, while still allowing cultivation of crops.
- ii. **Justify** the solution proposed in part I (i) by explaining one potential advantage other than reducing nutrient runoff.

The local government of a newly built town has contracted with an electrical company to provide energy to the town. The company generates electricity primarily through the burning of coal and has built a new power plant for the town. A nearby deposit of coal was discovered close to the surface. To access the coal, the company decides to remove the overburden and vegetation over the deposit.

3. Respond to parts A, B, C, D, E, F, and G.

A. **Identify** a type of surface mining the company could use to access the coal.

B. **Describe** an environmental problem associated with surface mining.

C. The town is located downwind of the new coal-burning power plant.

Describe an environmental problem the town could experience as a result of the electricity generation at the coal-burning power plant.

D. The local government is concerned about the environmental consequences of using coal to generate electricity for the town.

Propose a realistic solution the local government could enact that would reduce the negative environmental consequences of using coal to generate electricity.

E. Burning one pound of coal produces an average of 0.88 kilowatt-hours (kWh) of electricity. An average household in the United States uses 1.064×10^4 kWh of electricity each year.

Calculate how many pounds of coal would need to be burned to generate enough electricity to power a town with 11,000 houses for a year. **Show** your work.

F. Researchers are concerned about the impact of noise pollution on songbirds in a forest near the power plant. Since the power plant was installed, bird species richness has declined from 7.5 species per hectare to 6.0 species per hectare.

Calculate the percent change in bird species per hectare since the power plant was installed. **Show** your work.

G. The town has been growing since it was built and had a growth rate of 5.38% in 2022, with a population of 26,250.

Assuming that the growth rate remains constant, **calculate** the year in which the population will reach 52,500. **Show** your work.

STOP

END OF EXAM

3. Earth's climate has changed over time by the addition of greenhouse gasses to the atmosphere. One approach to mitigate climate change is the use of nuclear power, rather than coal-burning power plants, for electricity generation.

(a) **Identify** a fuel used in a nuclear power plant.

(b) **Describe** a negative environmental impact on nearby bodies of water that is caused by using water for cooling in nuclear power plants.

(c) In 2021, 4.1×10^{12} kilowatt hours (kWh) of commercial electricity was generated in the United States.

Nuclear power accounted for 18.9% of the total commercial electricity. **Calculate** the amount of electricity in kWh generated by nuclear power in the United States in 2021. **Show** your work.

Another approach to reduce greenhouse gas emissions is to switch from coal-burning power plants to natural gas power plants.

(d) In addition to reducing greenhouse gas emissions, **describe** how switching from coal-burning power plants to natural gas power plants will improve air quality.

Researchers have proposed large-scale tree planting as a solution to reduce the effects of fossil fuel combustion on global climate change.

(e) **Justify** the proposed solution by explaining an additional advantage, other than the reduction of atmospheric greenhouse gases.

(f) 7.4×10^7 cubic meters of natural gas were extracted from a large deposit in 2020. An average of 4.76 kWh of electricity can be generated from each cubic meter of natural gas combusted. In 2020, an average home consumed 10,715 kWh of electricity. **Calculate** how many homes could have been provided with electricity by natural gas extracted from the large deposit in 2020. **Show** your work.

(g) In 2021, 8.99×10^{11} kWh of electricity was generated through the combustion of coal. One kilogram of carbon dioxide is produced per kWh of electricity generated by combusting coal, while 0.42 kilograms of carbon dioxide is produced by combusting natural gas. **Calculate** how much less carbon dioxide would have been produced in 2021 if all coal-burning power plants were replaced with natural gas-burning power plants. **Show** your work.

Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.

STOP

END OF EXAM

3. Crude oil is extracted, transported, and refined for various uses by humans.

- (a) **Describe** one environmental impact on marine ecosystems associated with extraction or transportation of crude oil.
- (b) **Identify** an atmospheric pollutant released during the combustion of refined oil products.
- (c) **Propose** a solution an individual can use to reduce their reliance on refined oil products for transportation.
- (d) **Justify** the solution proposed in part (c) by providing a benefit to human health.

Other natural resources, such as gold and silver, are also extracted. These resources can be used to make components for the electronics humans use. One metric ton of gold ore contains 5.0 grams of gold.

- (e) A deposit is estimated to contain 260 million metric tons of gold ore. **Calculate** the number of grams of gold that could be extracted from the deposit. **Show** your work.
- (f) Assuming the price of gold is \$62.56 per gram, **calculate** the value of the gold that could be recovered from 1,000 metric tons of gold ore in the deposit. **Show** your work.
- (g) A typical cell phone contains 0.034 grams of gold. **Calculate** how many metric tons of gold ore would need to be mined to extract enough gold to manufacture 100,000 cell phones. **Show** your work.

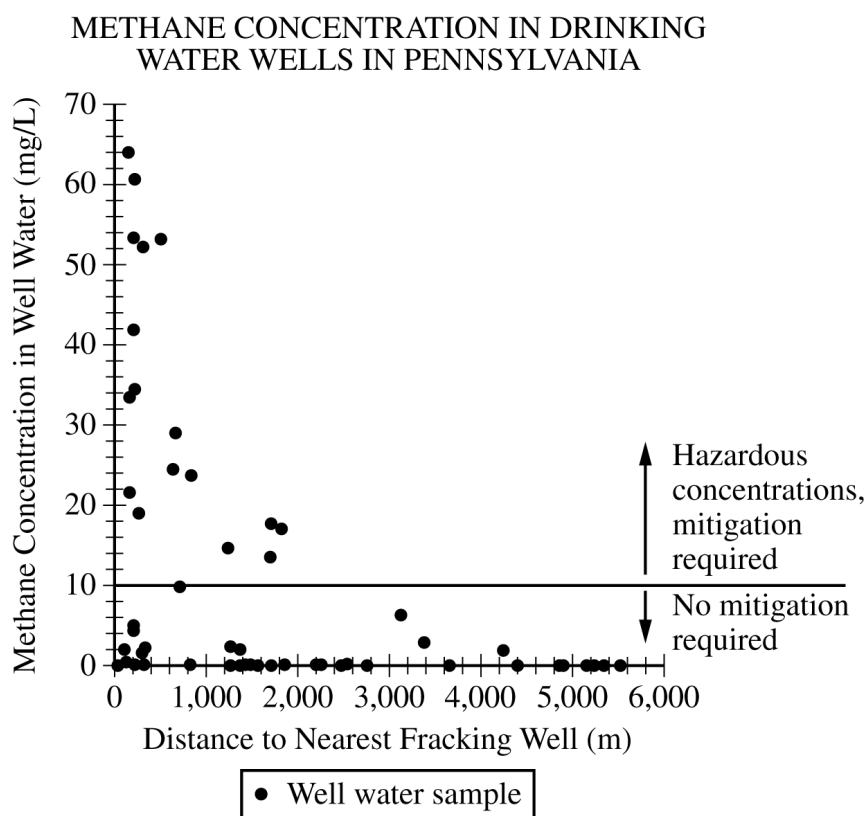
Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.

STOP

END OF EXAM



2. Developments in advanced hydraulic fracturing (fracking) technologies have allowed the total oil and gas production in the United States to increase rapidly.



- (a) The graph shows the methane concentration in drinking water from home wells and the distance to the nearest fracking well in Pennsylvania.
- Based on the data in the graph, **identify** the highest methane concentration found in well water in Pennsylvania.
 - Based on the data in the graph, **describe** the relationship between the concentration of methane in well water and the distance to a fracking well.
 - Based on the data in the graph, **identify** the minimum safe distance that a new water well should be located from an existing fracking well.
 - Explain** how fracking fluid is used to access oil and natural gas in sedimentary rock, such as shale, during the fracking process.
 - Identify** one negative geologic effect in an area where hydraulic fracturing (fracking) occurs.
- (b) The volume of water used for oil and gas extraction is 28 times greater than it was fifteen years ago. Much of the water used for oil and gas extraction comes from groundwater sources in arid or semiarid regions. This increased use of water for fracking may mean that less water is available for local use.
- The use of groundwater for fracking is an example of individuals using a shared resource for their own self-interest. **Identify** the environmental concept illustrated by this example of overuse of a shared resource.
 - Describe** one environmental problem that may result from increased use of groundwater for fracking in arid or semiarid regions.
 - Describe** how overuse of coastal groundwater supplies can result in water that is unsuitable for human consumption.

- (c) In addition to water quality issues caused by fossil fuel extraction, air quality can also be negatively affected by combustion of oil and natural gas.
- (i) **Make a claim** for a realistic governmental action to improve air quality by reducing consumption of oil.
 - (ii) **Justify** the action proposed in part (c)(i) by stating a potential environmental advantage of that action, other than slowing global climate change.

Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.

3. Approximately 350 coal-fired power plants in the United States are older than the 30-year anticipated life-span for a coal generator. One problem with these aging power plants is that many lack the necessary modern air pollution controls. Additionally, there are concerns about rising fuel costs, so many utility companies are planning to retire coal-fired plants and build new natural-gas power plants.

- (a) **Describe** why coal is considered a nonrenewable energy source.
- (b) **Describe** one potential environmental advantage of replacing a coal-fired power plant with a natural-gas power plant.
- (c) **Describe** one economic advantage of using natural gas, rather than coal, in producing electricity.
- (d) When natural gas is used to heat homes, it can produce carbon monoxide gas, which can lead to carbon monoxide poisoning in humans. **Propose** a solution to reduce the incidence of carbon monoxide poisoning in humans.

Particulate matter is another common pollutant in emissions from vehicles, coal-fired power plants, and various other sources. One size of particulates, $\text{PM}_{2.5}$, presents a particular risk to human health.

ATMOSPHERIC CONCENTRATION OF PARTICULATE MATTER IN 1990 AND 2016

Year	Average Annual Atmospheric Concentration of $\text{PM}_{2.5}$ ($\mu\text{g}/\text{m}^3$)
1990	85
2016	188

- (e) **Calculate** the percent change in the average annual $\text{PM}_{2.5}$ concentration in the air from 1990 to 2016. **Show** your work.
- (f) Trees can remove $\text{PM}_{2.5}$ from the atmosphere when particulates settle on the leaves and are subsequently washed onto soil by rain. The average annual removal of $\text{PM}_{2.5}$ is 2.3 kilograms per hectare. **Calculate** the decrease in $\text{PM}_{2.5}$ removal in kilograms if logging reduced a forested area from 50,000 hectares to 43,000 hectares. **Show** your work.
- (g) Research has shown that hospital admissions for cardiovascular problems increase 1% with every 10% increase in $\text{PM}_{2.5}$ concentration. A city experienced a 23% increase in $\text{PM}_{2.5}$ concentration and had 7,390 hospital admissions for cardiovascular issues over a one-year period. **Calculate** the anticipated increase in the number of hospital admissions for cardiovascular issues during the next year if the $\text{PM}_{2.5}$ concentration continues to rise at an identical rate. **Show** your work.

Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.

STOP

END OF EXAM

2. As conventional sources of crude oil are depleted, unconventional sources such as oil sands (also known as tar sands) are being utilized. Oil sands contain bitumen, which can be processed into a synthetic crude oil. A region of boreal forest in Alberta, Canada, that covers a deposit of oil sands will be cut and removed during the process of bitumen extraction. It is estimated that the deposit contains 73 billion barrels of recoverable bitumen. The rate of extraction from the deposit will be approximately 1 million barrels of bitumen per day.
- (a) **Identify** one ecological benefit, other than providing habitat, that is provided by forests.
 - (b) **Identify** one economic benefit that is provided by forests.
 - (c) **Describe** TWO environmental consequences, other than those related to the loss of boreal forest habitat, that result from the extraction of bitumen or the transportation of synthetic oil to customers.
 - (d) Assuming the above extraction rate, **calculate** how many days will be needed to extract the recoverable volume of bitumen from the oil sands.
 - (e) **Calculate** how many years will be needed to fully extract the recoverable volume of bitumen from the oil sands.
 - (f) Monthly production of synthetic crude oil is 30 million barrels. Producing one barrel of synthetic crude oil uses two barrels of heated freshwater. **Calculate** the number of barrels of freshwater needed each year to supply this demand.

ENVIRONMENTAL SCIENCE**SECTION II****Time—1 hour and 30 minutes****4 Questions**

Directions: Answer all four questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers on the pages following the questions in this book. Where calculations are required, clearly show how you arrived at your answer. Where explanation or discussion is required, support your answers with relevant information and/or specific examples.

1. Read the following article from the *Fremont Daily Times* and answer the questions that follow.

Fremont Daily Times**May 1, 2018****GREEN IS THE NEW SCHOOL COLOR AT FREMONT HIGH SCHOOL!**

A group of students from Fremont High School addressed the city council last night and proposed that one of the existing buildings at Fremont High School, which was built in 1970, be renovated to take advantage of recent advances in green technology. Currently the heat for the school is provided by fossil fuel combustion. The students said that the redesigned building would reduce the school's carbon footprint, which is a measure of the amount of carbon dioxide and other carbon compounds released by various human activities. Incorporating specific features that conserve energy and utilize

renewable energy sources can help reduce the carbon footprint.

Councilperson Gail Fassler praised the idea, saying that the project could conserve local water resources, reduce the need for consuming new resources, and act as a “shining beacon” of sustainability for the greater Fremont community. Fassler suggested the project could even incorporate a living green roof as an additional sustainable feature. The council approved the initial site planning request and urged students to report back when the project was under way.

- (a) The students want to reduce the school's carbon footprint.
- (i) **Define** carbon footprint.
 - (ii) **Identify** one way the school's heating system is likely adding to the school's carbon footprint.
 - (iii) **Describe** one realistic way to reduce the contribution of the heating system to the school's carbon footprint.
- (b) **Identify** TWO environmental benefits of a living green roof, such as that suggested by Councilperson Fassler.
- (c) **Describe** TWO practices the cafeteria's food service could use to decrease the environmental impacts of Fremont High School.
- (d) **Discuss** TWO benefits of using native plants for landscaping at Fremont High School.
- (e) During the renovation, the carpeting must be replaced. **Discuss** one environmental benefit of using flooring made of plant material, such as cork or bamboo, instead of carpet made of synthetic fibers.

2. Iron ores are rocks from which metallic iron can be extracted for steel production. This process involves several steps. Iron ore is first mined and then turned into pig iron in a blast furnace, and some rock waste such as silicon dioxide is separated out. In the final step, the pig iron is refined into steel using a process that includes reacting the molten pig iron with oxygen to remove impurities.

(a) Use the data below to respond to the following. For each calculation, show all your work.

Global Iron and Steel Data
1.6 billion tons of iron ore are used yearly to make pig iron.
1.2 billion tons of pig iron are produced each year.
Iron ore reserves are estimated to be 800 billion tons.
95% of iron ore that is mined is used in steel production.

- (i) **Calculate** the weight (in tons) of rock waste produced globally each year when iron ore is converted to pig iron.
- (ii) **Calculate** the weight (in tons) of pig iron that could be produced if all of the estimated global iron ore reserves were used for pig iron production.
- (iii) **Calculate** the weight (in tons) of the current global iron ore reserves that would be used to make steel if the current trends continue.

Both iron ore and coal are mined for use in the manufacture of steel. It is estimated that for every ton of steel recycled, 1.25 fewer tons of iron ore and 0.7 fewer tons of coal must be mined. About 80 million tons of steel are recycled each year in North America.

- (b) **Calculate** the weight (in tons) of coal that is conserved each year in North America by recycling steel.

Before the year 1900, most mining companies abandoned surface and subsurface coal mine sites once the resource was depleted.

- (c) **Describe** TWO environmental problems that are associated with abandoned coal mine sites.
- (d) **Describe** one method that can be used to mitigate one of the problems you identified in part (c).
- (e) **Discuss** one reason why surface coal mining is generally less expensive than subsurface mining.

6.6 Nuclear Power

Name: _____ Class: _____ Date: _____

Total: 10 marks**KEY WORDS** nuclear power 核能 • waste 核废料 • fission 裂变 • nuclear fission 核裂变 • methane 甲烷

Objective

Build the skills to answer exam questions on **nuclear power**.

You must be able to:

- describe **nuclear fission** 核裂变 to generate electricity
- state advantages (no CO₂, high energy density)
- state disadvantages (radioactive waste, accidents)

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ How it works

Nuclear power splits uranium atoms (**fission**), releasing huge heat that boils water to spin a turbine — generating electricity, like a steam plant but with a nuclear heat source.

■ Advantages

- Produces **no CO₂** during operation (helps climate).
- **Very high energy density** — a tiny amount of fuel yields a lot of energy.
- Reliable “baseload” power.

■ Disadvantages

- **Radioactive waste** stays dangerous for thousands of years and must be stored safely.
- Risk of **accidents** (Chernobyl, Fukushima) releasing radiation.
- High cost and **thermal pollution** of cooling water.
- Uranium is **nonrenewable**.

■ A worked judgement

Nuclear power is low-carbon and energy-dense, but the long-lived waste and accident risk make it controversial.

2 Practice

Now apply the methods above.

2.1 What process generates the heat in a nuclear plant? [1]

2.2 State one advantage of nuclear power. [1]

2.3 State one disadvantage. [1]

3 Exam-style questions

3.1 A climate advantage of nuclear power is that it [1]

- **A** produces no CO₂ during operation
 - **B** burns coal
 - **C** releases methane
 - **D** needs no fuel
-

3.2 A country considers building nuclear plants to cut carbon emissions.

(a) State one benefit and one drawback. [2]

(b) Explain the main challenge of nuclear waste. [2]

3.3 Explain why nuclear power is low-carbon but still not fully renewable. [2]

Solutions

2.1 Nuclear fission (splitting uranium atoms).

2.2 Any one: no CO₂, high energy density, reliable.

2.3 Any one: radioactive waste, accident risk, high cost, thermal pollution.

3.1 A — produces no CO₂ during operation.

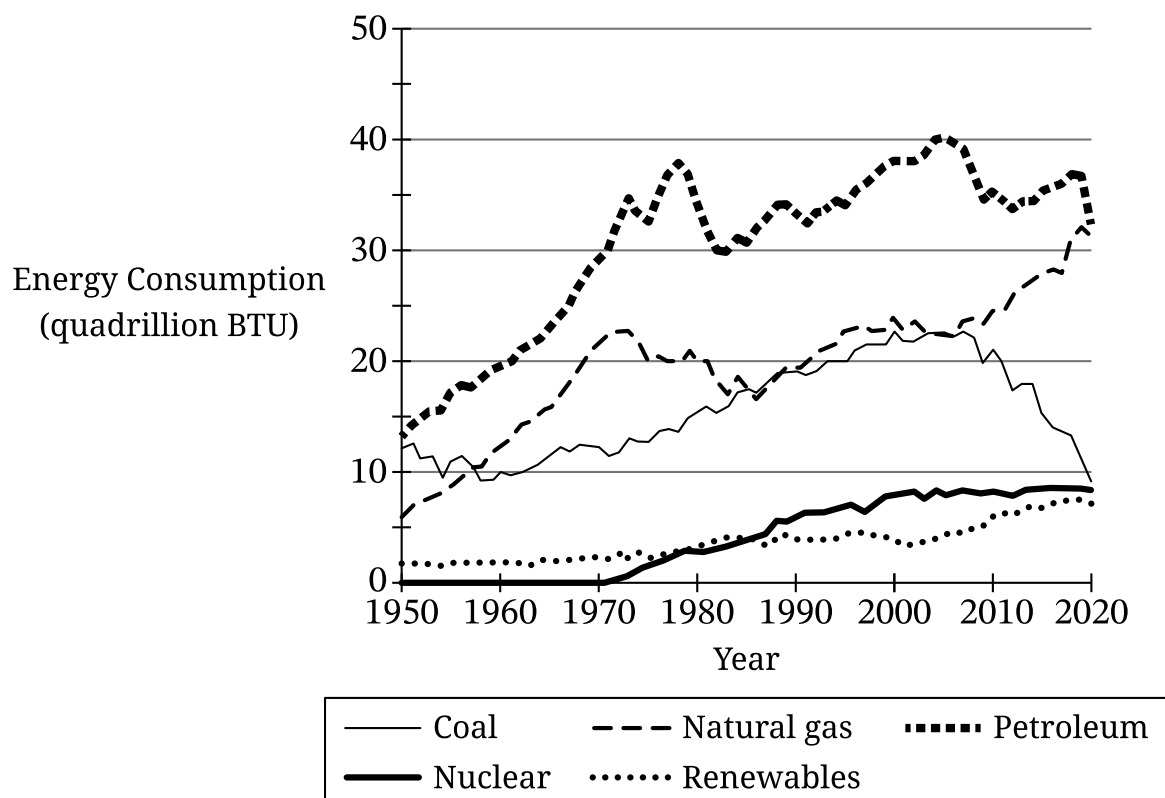
3.2 (a) Benefit: low-carbon, energy-dense power; drawback: radioactive waste or accident risk. (b) The waste stays radioactive and dangerous for thousands of years, so it must be stored safely for a very long time.

3.3 It emits no CO₂ during operation, but its fuel (uranium) is a finite mined element, so it is nonrenewable.

The following information applies to parts A, B, C, D, E, F, and G.

The following graph shows the number of quadrillion British thermal units (BTUs) that were consumed in the United States using five different energy sources from 1950 to 2020.

Energy Consumption by Source in the United States, 1950–2020



The following information applies to parts H and I.

Researchers studied an aquatic ecosystem near an area of land that had been converted to agricultural use. They reported an increase in nutrients, such as nitrates and phosphates, in the water.

2. Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

Part A

Identify one renewable energy source that is used to generate electricity.

Part B

Based on the data in the graph, **identify** the energy source that had the highest consumption in 2010.

Part C

Based on the data in the graph, **describe** the pattern in the energy consumption from coal in the United States from 1960 to 2020.

Part D

Based on the data in the graph and your knowledge of energy consumption, **explain** one likely reason why the use of coal for energy changed between 2010 and 2020.

Part E

Explain how fossil fuels are used to generate electricity.

Part F

In addition to fossil fuels, nuclear power can be used to generate electricity. **Identify** one negative impact associated with nuclear energy.

Part G

Fossil fuel combustion leads to ocean warming. **Describe** one environmental problem other than coral bleaching that is associated with warming oceans.

Part H

Explain how an increase in nutrients, such as nitrates and phosphates, can negatively affect an aquatic ecosystem.

Part I

- i. **Propose** a realistic solution that would reduce nutrient pollution of waterways, while still allowing cultivation of crops.
- ii. **Justify** the solution proposed in part I (i) by explaining one potential advantage other than reducing nutrient runoff.

3. Earth's climate has changed over time by the addition of greenhouse gasses to the atmosphere. One approach to mitigate climate change is the use of nuclear power, rather than coal-burning power plants, for electricity generation.

(a) **Identify** a fuel used in a nuclear power plant.

(b) **Describe** a negative environmental impact on nearby bodies of water that is caused by using water for cooling in nuclear power plants.

(c) In 2021, 4.1×10^{12} kilowatt hours (kWh) of commercial electricity was generated in the United States.

Nuclear power accounted for 18.9% of the total commercial electricity. **Calculate** the amount of electricity in kWh generated by nuclear power in the United States in 2021. **Show** your work.

Another approach to reduce greenhouse gas emissions is to switch from coal-burning power plants to natural gas power plants.

(d) In addition to reducing greenhouse gas emissions, **describe** how switching from coal-burning power plants to natural gas power plants will improve air quality.

Researchers have proposed large-scale tree planting as a solution to reduce the effects of fossil fuel combustion on global climate change.

(e) **Justify** the proposed solution by explaining an additional advantage, other than the reduction of atmospheric greenhouse gases.

(f) 7.4×10^7 cubic meters of natural gas were extracted from a large deposit in 2020. An average of 4.76 kWh of electricity can be generated from each cubic meter of natural gas combusted. In 2020, an average home consumed 10,715 kWh of electricity. **Calculate** how many homes could have been provided with electricity by natural gas extracted from the large deposit in 2020. **Show** your work.

(g) In 2021, 8.99×10^{11} kWh of electricity was generated through the combustion of coal. One kilogram of carbon dioxide is produced per kWh of electricity generated by combusting coal, while 0.42 kilograms of carbon dioxide is produced by combusting natural gas. **Calculate** how much less carbon dioxide would have been produced in 2021 if all coal-burning power plants were replaced with natural gas-burning power plants. **Show** your work.

Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.

STOP

END OF EXAM

ENVIRONMENTAL SCIENCE**SECTION II****Time—90 minutes****4 Questions**

Directions: Answer all four questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers on the pages following the questions in this book. Where calculations are required, clearly show how you arrived at your answer. Where explanation or discussion is required, support your answers with relevant information and/or specific examples.

1. Read the article below and answer the questions that follow.

The Fremont Plaindealer**May 1, 2013**

Last night the county council discussed a motion to support the construction of a new nuclear power plant on the Fremont River to address the rising demand for electrical power in Fremont County. Councilperson Pamela Kull spoke in support of the plant, remarking that “nuclear power plants produce no dangerous solid waste” and “using nuclear power avoids the release of

greenhouse gases.”

Councilperson Chinh Serach said that Dr. Kull’s remarks were incorrect and then introduced a different motion to provide funding to help Fremont homeowners and businesses reduce electricity use. He stated that such steps could make building the nuclear plant unnecessary.

- (a) State whether you agree or disagree with each of the following remarks made by Dr. Kull. For each remark, provide one justification for your position.
- (i) “Nuclear power plants produce no dangerous solid waste.”
 - (ii) “Using nuclear power avoids the release of greenhouse gases.”
- (b) If the plan for a nuclear power plant in Fremont is approved, it will take several years for the plant to be built. **Describe** TWO environmental problems that could result from the construction of the plant (i.e., prior to operation).
- (c) Suppose that the nuclear power plant is constructed on the Fremont River site.
- (i) **Identify** the most likely pollution threat that the plant will pose to the Fremont River as a result of the plant’s normal daily operation.
 - (ii) **Discuss** one potential ecological consequence of the pollution threat that you identified in part (i).
 - (iii) **Identify** a system often used in nuclear power plants to reduce the pollution you identified in part (i).
- (d) **Describe** TWO specific steps that Fremont residents and/or businesses could take to reduce the use of electricity.
- (e) **Identify** a specific nuclear power plant at which a major accident has occurred. **Explain** one environmental consequence (other than effects on human health) of a nuclear power plant accident.

6.7 Energy from Biomass

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS biomass 生物质 • ethanol 乙醇 • waste 核废料 • fossil fuels 化石燃料

Objective

Build the skills to answer exam questions on **energy from biomass**.

You must be able to:

- describe **biomass** 生物质 energy (wood, crops, biofuels)
- explain that it is renewable but has impacts
- discuss carbon neutrality and air pollution

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Biomass energy

Biomass is energy from organic material — burning **wood**/crop waste, or making **biofuels** (ethanol from corn, biodiesel). It is **renewable** if replanted.

■ Carbon (near-)neutral

Growing biomass **absorbs** CO₂, and burning it **releases** the same CO₂ back — so it can be roughly **carbon neutral** over its cycle (unlike fossil fuels, which add ancient carbon).

■ Disadvantages

- Burning still releases **air pollution** (particulates).
- Growing biofuel crops competes with **food** production and can drive land clearing.
- Only sustainable if regrown as fast as used.

■ A worked judgement

Ethanol from corn is renewable and near carbon-neutral, but growing the corn uses land, water, and fertilizer and competes with food.

2 Practice

Now apply the methods above.

2.1 Give one example of biomass energy. [1]

2.2 Why can biomass be roughly carbon neutral? [1]

2.3 State one disadvantage of biofuel crops. [1]

3 Exam-style questions

3.1 Biomass can be considered carbon neutral because growing it [1]

- **A** releases CO₂
 - **B** absorbs the CO₂ that burning releases
 - **C** produces no gases
 - **D** uses fossil fuels
-

3.2 A country grows corn to make ethanol fuel.

(a) State one benefit and one drawback. [2]

(b) Explain why biomass is renewable only if managed well. [2]

3.3 Explain why burning biomass is often considered better for the climate than burning coal. [2]

Solutions

2.1 Any one: burning wood/crop waste, ethanol, biodiesel.

2.2 Growing it absorbs the same CO_2 that burning releases.

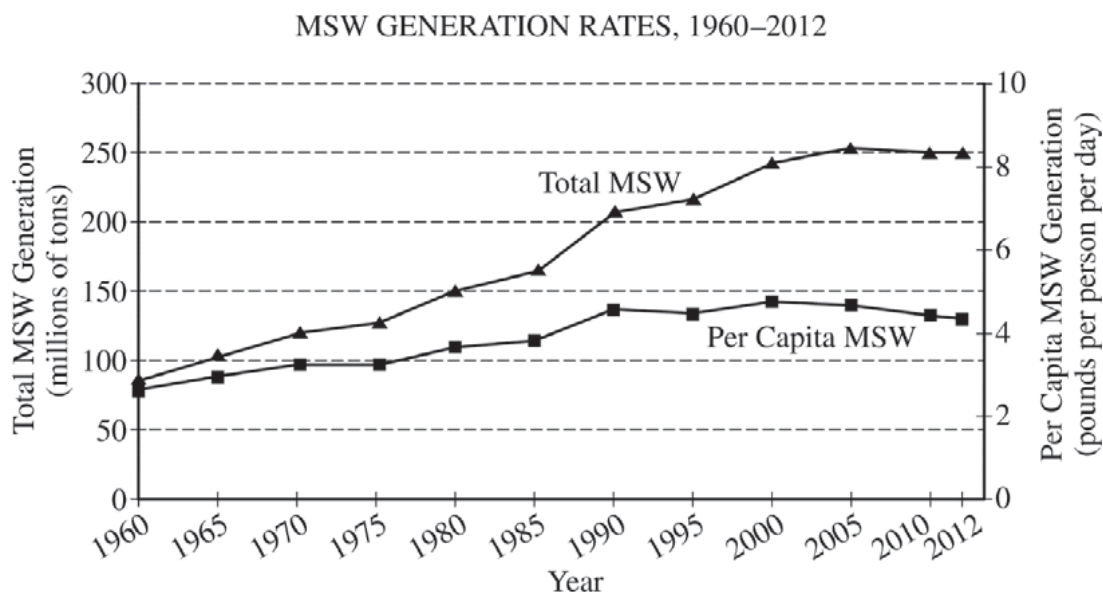
2.3 Any one: competes with food, uses land/water/fertilizer, air pollution.

3.1 B — absorbs the CO_2 that burning releases.

3.2 (a) Benefit: renewable and near carbon-neutral; drawback: competes with food or causes air pollution. (b) It is renewable only if the plants are regrown as fast as they are burned; otherwise the resource is depleted.

3.3 Biomass returns recently-absorbed CO_2 (near carbon-neutral), while coal releases carbon stored for millions of years, adding new CO_2 to the atmosphere.

3. Municipal solid waste (MSW) is the trash collected from households and businesses. The graph below shows MSW generation in the United States from 1960 to 2012.



- (a) Use the data provided in the graph above to respond to the following.
- Explain** one probable cause (other than increased composting) for the change in per capita waste generation from 2000 to 2012.
 - Calculate** the percent increase in total MSW generation from 1980 to 2012.
- (b) Two ways of managing MSW are incineration and disposal in landfills.
- Identify** one disadvantage of waste incineration.
 - Identify** one disadvantage of waste disposal in landfills.

Trash incineration is one way to generate electricity from MSW. Electricity can also be generated from waste buried in landfills.

- (c) **Describe** the specific steps of a process used to produce electricity from waste buried in a landfill.
- (d) Many landfills do not accept used tires. As a result, the tires are often dumped in poorly regulated piles. **Describe** one human health problem associated with piles of discarded tires.
- (e) Composting is one way to reduce the amount of waste that enters a landfill.
- Other than reducing the volume of waste, **identify** one advantage of composting.
 - Identify** one disadvantage of composting.

6.8 Solar Energy

Name: _____ Class: _____ Date: _____

Total: 10 marks**KEY WORDS** solar 太阳能 • photovoltaic 光伏 • active/passive solar 主动 • wind 风能 • biomass 生物质

Objective

Build the skills to answer exam questions on **solar energy**.

You must be able to:

- distinguish **photovoltaic (PV)** 光伏 and **active/passive solar** 主动/被动太阳能
- state advantages and disadvantages
- explain intermittency

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Types of solar

- **Photovoltaic (PV) cells** — convert sunlight **directly** into electricity.
- **Active solar** — uses pumps/fans to move solar-heated water/air (e.g. solar water heaters).
- **Passive solar** — building design (windows, materials) that captures heat without machines.

■ Advantages

- **Renewable**, no CO₂ during use.
- No fuel cost; low maintenance; works off-grid.

■ Disadvantages

- **Intermittent** — no power at night or when cloudy (needs storage/batteries).
- Manufacturing has some impact; needs space; upfront cost.

■ A worked judgement

Solar PV is clean and renewable, but because it is **intermittent**, it needs batteries or a backup supply for constant power.

2 Practice

Now apply the methods above.

2.1 What does a photovoltaic cell do? [1]

2.2 What is passive solar design? [1]

2.3 Why is solar power called intermittent? [1]

3 Exam-style questions

3.1 A photovoltaic cell converts sunlight directly into [1]

- **A** heat only
 - **B** electricity
 - **C** biomass
 - **D** wind
-

3.2 A home installs solar panels.

(a) State one advantage and one disadvantage. [2]

(b) Explain how the intermittency problem can be addressed. [2]

3.3 Explain the difference between active and passive solar heating. [2]

Solutions

2.1 Converts sunlight directly into electricity.

2.2 Building design that captures solar heat without machines.

2.3 It produces no power at night or when cloudy.

3.1 B — electricity.

3.2 (a) Advantage: renewable, no CO₂, no fuel cost; disadvantage: intermittent or high upfront cost. (b) Store energy in batteries (or use a backup/grid) for use when the sun is not shining.

3.3 Active solar uses pumps/fans to move solar-heated water or air; passive solar uses building design (windows, materials) to capture heat with no machines.

3. Increasing global urbanization causes associated problems such as the formation of urban heat islands.

(a) **Describe** how urbanization leads to the formation of urban heat islands.

(b) Urban heat islands have been linked to a variety of environmental problems.

(i) **Propose** a reasonable solution that could help lower the temperature increases caused by urban heat islands.

(ii) **Justify** the solution proposed in part (b)(i) by providing one additional benefit other than reducing temperatures in urban heat islands.

(c) Urban areas are increasingly using solar energy to generate electricity for residences and businesses.

(i) As a result of improved technology, the efficiency of solar panels has changed over time. In 1992 a solar cell had a maximum efficiency of 15.9%. In 2017 a solar cell prototype capable of 44.5% efficiency was produced. **Calculate** the percent change in efficiency from the 1992 cell to the 2017 cell. **Show** your work.

(ii) The average home in the United States uses 12,900 kWh of electricity per year. The local power company is raising the cost of purchasing electricity from \$0.11 per kWh to \$0.13 per kWh. Assuming a home uses the average kWh of electricity in one year, **calculate** the change in electricity cost for one year for the homeowner. **Show** your work.

(iii) The roof of a typical house in the United States receives a total of four hours of sunlight per day that can be converted by solar panels into electricity. A house has 30 solar panels on its roof, and each panel generates a maximum output of 300 watts. **Calculate** how many kWh can be produced by the system at maximum output in one calendar year. **Show** your work.

(d) **Explain** why the Northern Hemisphere receives more solar energy from the Sun between June and August than the Southern Hemisphere receives between June and August.

Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.

STOP

END OF EXAM

6.9 Hydroelectric Power

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS dam 大坝 • hydroelectric 水电 • reservoir 水库 • fossil fuels 化石燃料

Objective

Build the skills to answer exam questions on **hydroelectric power**.

You must be able to:

- describe how a **dam** 大坝 generates electricity
- state advantages (renewable, no CO₂) and disadvantages (habitat, displacement)
- explain effects on rivers and fish

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ How it works

Hydroelectric power uses falling or flowing water (usually from a **dam**) to spin turbines and generate electricity. It is **renewable** and emits no CO₂ during operation.

■ Advantages

- Renewable, low-carbon, reliable.
- Reservoirs provide water storage and flood control.

■ Disadvantages

- The **reservoir floods** land, destroying habitat and displacing people.
- **Blocks fish migration** (e.g. salmon) unless fish ladders are built.
- **Traps sediment**, starving downstream areas of nutrients.
- Changes river flow and temperature.

■ A worked judgement

A large dam gives clean, reliable power but floods a valley, blocks fish, and traps sediment — significant ecological trade-offs.

2 Practice

Now apply the methods above.

2.1 What spins the turbines in a hydroelectric plant? [1]

2.2 State one advantage of hydroelectric power. [1]

2.3 State one disadvantage. [1]

3 Exam-style questions

3.1 A major ecological drawback of a large dam is that it [1]

- **A** produces CO₂
 - **B** blocks fish migration and floods habitat
 - **C** uses fossil fuels
 - **D** cannot store water
-

3.2 A country builds a large dam for electricity.

(a) State one benefit and one environmental cost. [2]

(b) Explain how the dam affects fish and sediment. [2]

3.3 Explain why hydroelectric power is renewable and low-carbon. [2]

Solutions

2.1 Falling/flowing water (from the dam).

2.2 Any one: renewable, no CO₂, reliable, water storage/flood control.

2.3 Any one: floods habitat, displaces people, blocks fish, traps sediment.

3.1 B — blocks fish migration and floods habitat.

3.2 (a) Benefit: clean, reliable, renewable power; cost: flooded habitat / displaced people / blocked fish. (b) The dam blocks migrating fish (unless fish ladders exist) and traps sediment, starving downstream areas of nutrients.

3.3 It uses the water cycle (endlessly replenished by rainfall) to generate power and burns no fuel, so it emits no CO₂ during operation.

2. An offshore wind farm project using turbines to generate electricity is to be built along the Atlantic coast of the United States. It will be located about 13 km from the coast in water with an average depth of 10 m.
- (a) **Describe** one environmental benefit associated with an offshore wind project.
 - (b) **Identify** and **describe** one potential economic effect of an offshore wind project.
 - (c) **Describe** one additional way, other than wind power, that oceans can provide renewable energy for the generation of electricity.

The project will consist of 200 wind turbines, each with a capacity of 4 megawatts (MW). Each turbine costs \$1.2 million to build. Electrical demand in the area to be served by the project is expected to be 2.0×10^6 MWh per year.

- (d) **Calculate** how much electricity (in MWh) the wind project needs to generate per year in order to provide 80% of the annual electrical demand in the service area. Show all work.
- (e) Customers in the service area pay \$0.20/kWh for electricity. **Calculate** how much revenue will be produced if the wind turbines provide 80% of the annual electrical demand in the service area. Show all work.
- (f) Assuming all turbines are operating, **calculate** how many hours the wind turbines must operate to provide 80% of the annual electrical demand in the service area. Show all work.

4. Dams are built by humans for various purposes including hydroelectric power generation and control of downstream flooding.
- (a) **Explain** how electricity is generated at a hydroelectric dam.
 - (b) **Identify** TWO economic benefits, other than hydroelectric power generation and control of downstream flooding, associated with dams.
 - (c) **Describe** one ecological benefit of seasonal flooding of the floodplain of a free-flowing river.
 - (d) Some dams have been removed from rivers.
 - (i) **Explain** how removal of a dam can benefit fish populations.
 - (ii) **Describe** one negative environmental consequence of removing a dam from a river (other than effects on fish populations).
 - (e) Dams are also built by beavers, a keystone species in some North American ecosystems.
 - (i) **Define** keystone species.
 - (ii) **Describe** how dams built by beavers can make beavers a keystone species in some ecosystems.

STOP

END OF EXAM



6.10 Geothermal Energy

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS geothermal 地热 • steam 蒸汽 • wind 风能 • solar 太阳能

Objective

Build the skills to answer exam questions on **geothermal energy**.

You must be able to:

- describe **geothermal** 地热 energy from Earth's heat
- state advantages and disadvantages
- explain where it is most viable

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ How it works

Geothermal energy taps **Earth's internal heat**: hot water/steam from underground spins turbines to make electricity, or heats buildings directly.

■ Where it is viable

It is most practical near **plate boundaries and volcanic regions**, where heat is close to the surface (e.g. Iceland). Ground-source heat pumps work more widely for heating/cooling.

■ Advantages

- **Renewable**, reliable (works day and night), low CO₂.
- Small land footprint.

■ Disadvantages

- **Location-limited** — best only in geologically active areas.
- Can release some underground gases; high drilling cost.

■ A worked judgement

Iceland uses abundant geothermal energy because it sits on a plate boundary, but a geologically stable country has far less easily-accessible geothermal potential.

2 Practice

Now apply the methods above.

2.1 What is the source of geothermal energy? [1]

2.2 Where is geothermal energy most viable? [1]

2.3 State one advantage of geothermal power. [1]

3 Exam-style questions

3.1 Geothermal energy is limited mainly by [1]

- **A** the weather
 - **B** its dependence on geologically active locations
 - **C** the time of day
 - **D** the season
-

3.2 A country on a plate boundary develops geothermal power.

(a) State two advantages. [2]

(b) Explain why a geologically stable country cannot easily use it. [2]

3.3 Explain why geothermal energy is more reliable than solar or wind. [2]

Solutions

2.1 Earth's internal heat.

2.2 Near plate boundaries / volcanic regions.

2.3 Any one: renewable, reliable, low CO₂, small footprint.

3.1 B — its dependence on geologically active locations.

3.2 (a) Any two: renewable, reliable (24/7), low-carbon, small land use. (b) In a stable area the heat is deep underground and hard/expensive to reach, so it is not practical.

3.3 Earth's heat is available constantly (day and night, all weather), unlike solar (needs sun) and wind (needs wind), so geothermal provides steady baseload power.

6.11 Hydrogen Fuel Cell

Name: _____ Class: _____ Date: _____

Total: 9 marks

KEY WORDS hydrogen fuel cell 氢燃料电池 • fossil fuels 化石燃料 • methane 甲烷 • solar 太阳能
• wind 风能

Objective

Build the skills to answer exam questions on the **hydrogen fuel cell**.

You must be able to:

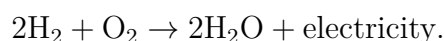
- describe a **hydrogen fuel cell** 氢燃料电池 (hydrogen + oxygen → water + electricity)
- state that the only emission is **water**
- explain why hydrogen is only as clean as its source

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ How it works

A **hydrogen fuel cell** combines **hydrogen and oxygen** to produce **electricity**, with **water** as the only by-product:



■ Advantages

- The only emission at use is **water** — no CO₂ or pollution.
- High efficiency; quiet; useful for vehicles.

■ The catch: making the hydrogen

Hydrogen must be **produced**. If it comes from **fossil fuels**, the overall process still emits CO₂. If made using **renewable** electricity (splitting water), it is truly clean.

■ A worked judgement

A fuel-cell car emits only water, but it is only “green” if the hydrogen was made with clean energy — otherwise the emissions are just moved to the production step.

2 Practice

Now apply the methods above.

2.1 What are the inputs to a hydrogen fuel cell? [1]

2.2 What is the only by-product at the point of use? [1]

2.3 Why might hydrogen not be fully clean? [1]

3 Exam-style questions

3.1 The only emission from a hydrogen fuel cell during use is [1]

- **A** carbon dioxide
 - **B** water
 - **C** methane
 - **D** nitrogen oxides
-

3.2 A car company markets hydrogen fuel-cell cars as “zero emission”.

(a) Explain why this is true at the point of use. [1]

(b) Explain why the full process may still cause emissions. [2]

3.3 Explain how hydrogen could be produced with no net carbon emissions. [2]

Solutions

2.1 Hydrogen and oxygen.

2.2 Water.

2.3 The hydrogen may be made using fossil fuels, which emit CO_2 .

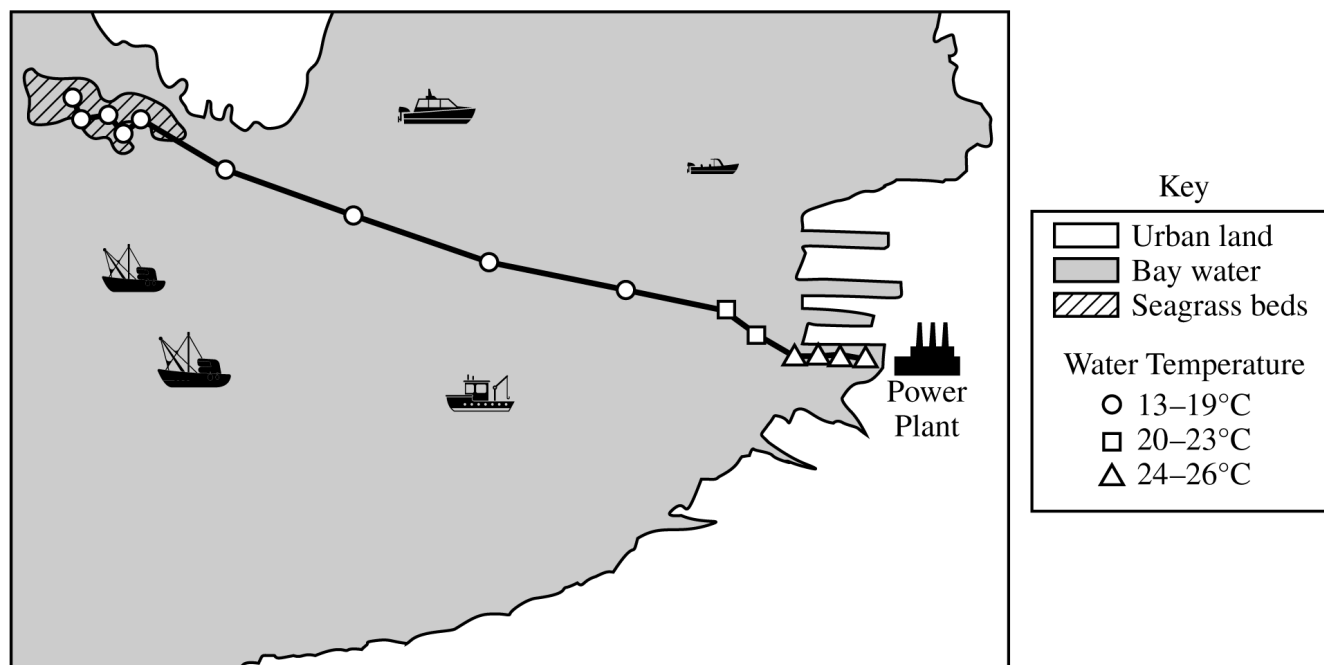
3.1 B — water.

3.2 (a) At the point of use it only produces water, no CO_2 . (b) Making the hydrogen often uses fossil-fuel energy, so CO_2 is emitted during production — the emissions are shifted, not removed.

3.3 Use renewable electricity (solar, wind) to split water into hydrogen and oxygen, so no fossil fuels are burned and there are no net carbon emissions.

2. The diagram shows the movement of one adult manatee over a 12-hour period across an active shipping channel during the winter. Manatees are large, aquatic, herbivorous mammals that primarily eat seagrass. Manatees can travel several miles to graze. Manatees mature slowly, have low biotic potential, and inhabit warm coastal waters. They cannot survive in water below 20°C for extended periods of time.

Satellite Track and Water Temperature Log of the Movement of One Adult Manatee Over a 12-Hour Period



- (a) Based on the information in the diagram, **identify** the temperature range of the water through which the majority of the adult manatee's daily movement occurs.
- (b) Large groups of manatees are often observed in shallow waters near the waste water released by the electrical power plant during the winter. Based on the information in the diagram, **identify** a characteristic of the power plant waste water that would attract the manatees.
- (c) Based on the information in the diagram, **describe** a potential negative impact of the waste water released by the power plant on other aquatic species.
- (d) Seagrass beds have declined significantly over the last several years. In 2021 manatee mortality was three times higher than the previous five-year average.
- (i) **Describe** a characteristic of the manatees that increases their vulnerability to the recent decline of seagrasses.
 - (ii) **Describe** the change in energy flow through the trophic levels that occurs when there is a significant loss of seagrasses.

(e) Research has shown increased nutrient and sediment runoff can cause seagrass beds to decline.

(i) **Propose** a solution to reduce nutrient or sediment pollution in an estuary that is surrounded by urban development.

(ii) **Justify** the solution proposed in part (e)(i) by providing an additional advantage of reduced nutrients in an estuary, other than one related to manatees.

Urban areas have a heavy dependence on automobiles and often experience photochemical smog.

(f) **Describe** how summertime weather conditions can increase the frequency of photochemical smog.

(g) **Identify** one ecological problem that results from exposure to photochemical smog.

A potential solution to reduce photochemical smog in urban areas with high automobile traffic is to replace gasoline-powered cars with cars powered by hydrogen fuel cells.

(h) **Describe** a potential disadvantage of using hydrogen fuel cells to power automobiles.

Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.

6.12 Wind Energy

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS wind turbines 风力涡轮机 • wind 风能

Objective

Build the skills to answer exam questions on **wind energy**.

You must be able to:

- describe how **wind turbines** 风力涡轮机 generate electricity
- state advantages and disadvantages
- explain intermittency and siting issues

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ How it works

Wind turbines use moving air to spin blades connected to a generator, producing electricity. Wind is a **renewable**, low-carbon source.

■ Advantages

- Renewable, **no CO₂** during use, no fuel cost.
- Land between turbines can still be farmed.

■ Disadvantages

- **Intermittent** — only works when the wind blows (needs storage/backup).
- Can **harm birds and bats**; noise and visual impact.
- Best only in consistently **windy** locations (coasts, plains, ridges).

■ A worked judgement

A wind farm on a windy coast provides clean power and lets the land below stay in use, but produces nothing on calm days and may affect local birds.

2 Practice

Now apply the methods above.

2.1 What spins a wind turbine's blades? [1]

2.2 State one advantage of wind energy. [1]

2.3 State one disadvantage. [1]

3 Exam-style questions

3.1 A disadvantage of wind power is that it is [1]

- **A** a major CO₂ source
 - **B** intermittent (depends on wind)
 - **C** nonrenewable
 - **D** available everywhere equally
-

3.2 A region installs a large wind farm.

(a) State one benefit and one drawback. [2]

(b) Explain how the intermittency problem could be managed. [2]

3.3 Explain why wind energy is considered renewable and low-carbon. [2]

Solutions

2.1 Moving air (wind).

2.2 Any one: renewable, no CO₂, no fuel cost, land still usable.

2.3 Any one: intermittent, harms birds/bats, noise/visual impact, location-limited.

3.1 B — intermittent (depends on wind).

3.2 (a) Benefit: clean, renewable power / dual land use; drawback: intermittent or harms birds. (b) Store surplus energy (batteries) or combine with other sources/backup for calm periods.

3.3 Wind is continually renewed by the Sun-driven atmosphere and burns no fuel, so it emits no CO₂ during operation.

2. An offshore wind farm project using turbines to generate electricity is to be built along the Atlantic coast of the United States. It will be located about 13 km from the coast in water with an average depth of 10 m.
- (a) **Describe** one environmental benefit associated with an offshore wind project.
 - (b) **Identify** and **describe** one potential economic effect of an offshore wind project.
 - (c) **Describe** one additional way, other than wind power, that oceans can provide renewable energy for the generation of electricity.

The project will consist of 200 wind turbines, each with a capacity of 4 megawatts (MW). Each turbine costs \$1.2 million to build. Electrical demand in the area to be served by the project is expected to be 2.0×10^6 MWh per year.

- (d) **Calculate** how much electricity (in MWh) the wind project needs to generate per year in order to provide 80% of the annual electrical demand in the service area. Show all work.
- (e) Customers in the service area pay \$0.20/kWh for electricity. **Calculate** how much revenue will be produced if the wind turbines provide 80% of the annual electrical demand in the service area. Show all work.
- (f) Assuming all turbines are operating, **calculate** how many hours the wind turbines must operate to provide 80% of the annual electrical demand in the service area. Show all work.

6.13 Energy Conservation

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS efficiency 效率 • conservation 节约 • energy conservation 节能

Objective

Build the skills to answer exam questions on **energy conservation**.

You must be able to:

- distinguish **conservation** 节约 from **efficiency** 效率
- give examples of each
- explain why conservation reduces impacts and cost

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Conservation vs efficiency

- **Energy conservation** — using less energy (turning off lights, driving less).
- **Energy efficiency** — getting the **same service using less** energy (LED bulbs, insulation, efficient appliances).

■ Examples of efficiency

LED lights, better insulation, hybrid/electric vehicles, and Energy Star appliances all deliver the same benefit with less energy.

■ Why it matters

Conservation and efficiency **reduce demand**, cutting fossil-fuel use, CO₂ emissions, and cost — often the **cheapest** way to reduce environmental impact.

■ A worked example

Replacing incandescent bulbs with LEDs is **efficiency** (same light, less energy); switching them off when not needed is **conservation** (using less).

2 Practice

Now apply the methods above.

2.1 What is energy conservation? [1]

2.2 Give one example of energy efficiency. [1]

2.3 Why does reducing energy demand help the environment? [1]

3 Exam-style questions

3.1 Installing better home insulation is an example of energy [1]

- **A** conservation (using less service)
 - **B** efficiency (same service, less energy)
 - **C** production
 - **D** extraction
-

3.2 A household wants to cut its energy use.

(a) Give one conservation action and one efficiency measure. [2]

(b) Explain how these reduce environmental impact. [2]

3.3 Explain why energy efficiency is often described as the cheapest way to cut emissions. [2]

Solutions

2.1 Using less energy.

2.2 Any one: LED bulbs, insulation, efficient appliances, hybrid cars.

2.3 It reduces fossil-fuel use and the CO₂ and pollution that go with it.

3.1 B — efficiency (same service, less energy).

3.2 (a) Conservation: e.g. turn off lights / drive less; efficiency: e.g. LED bulbs / insulation. (b) Using less energy lowers fossil-fuel demand, cutting CO₂ emissions and pollution.

3.3 Saving energy avoids the cost of generating it, and efficiency measures often pay for themselves through lower bills, so they cut emissions at negative or low net cost.

3. Respond to parts A, B, C, D, E, F, and G.

- A.** One major environmental problem is air pollution. Air pollution can come from natural or anthropogenic sources. Motor vehicles can be a source of particulate matter (PM) and other pollutants.

Identify an anthropogenic source of particulate matter, other than from motor vehicles.

- B.** One way to reduce pollutants associated with motor vehicles is to use a vapor recovery nozzle. **Describe** one way a vapor recovery nozzle is used to reduce atmospheric pollution.
- C.** Acid rain is another air pollutant linked to motor vehicles. Over the past few years, there has been an increase in the number of people working from home, so fewer people are commuting to work in their personal vehicles.

Explain how a decrease in the number of people commuting to work in their personal vehicles could lead to a reduction in acid rain.

- D.** The average gas mileage for a small gasoline-powered sport utility vehicle (SUV) is 22 miles per gallon (mpg) in the city. The average gas mileage for a small hybrid SUV is 36 mpg in the city. One commuter sells their gasoline-powered SUV and replaces it with a hybrid SUV.

Calculate the percent change in gas mileage between the gasoline-powered SUV and the hybrid SUV based on the data provided. **Show** your work.

- E.** Both the gasoline-powered SUV and the hybrid SUV have 14-gallon gas tanks. As stated in part D, the average gas mileage for a small gasoline-powered sport utility vehicle (SUV) is 22 miles per gallon (mpg) in the city. The average gas mileage for a small hybrid SUV is 36 mpg in the city.

Calculate how many more miles the owner can drive in the hybrid SUV in the city than they could have driven in the gasoline-powered SUV. **Show** your work.

- F.** In addition to vehicles, buildings such as schools often have high energy consumption. The primary sources of energy use in many buildings are heating, cooling, and lighting.

Propose a realistic solution that schools could implement to decrease energy use for heating and cooling, other than a reduction in the amount of time the school building is occupied.

- G.** The school plans to upgrade its lighting to save money and reduce both its electricity use and its ecological footprint. The sustainability committee proposes that the school reduce its electricity use by switching to energy-efficient light-emitting diode (LED) bulbs. The school building uses 2.8×10^4 bulbs. The LED bulbs would each use 0.0085 kilowatts per hour. Each bulb would be used for an average of 2,340 hours per year.

Calculate the energy use in the school building in kilowatts per year using LED light bulbs. **Show** your work.

STOP

END OF EXAM

3. Crude oil is extracted, transported, and refined for various uses by humans.

- (a) **Describe** one environmental impact on marine ecosystems associated with extraction or transportation of crude oil.
- (b) **Identify** an atmospheric pollutant released during the combustion of refined oil products.
- (c) **Propose** a solution an individual can use to reduce their reliance on refined oil products for transportation.
- (d) **Justify** the solution proposed in part (c) by providing a benefit to human health.

Other natural resources, such as gold and silver, are also extracted. These resources can be used to make components for the electronics humans use. One metric ton of gold ore contains 5.0 grams of gold.

- (e) A deposit is estimated to contain 260 million metric tons of gold ore. **Calculate** the number of grams of gold that could be extracted from the deposit. **Show** your work.
- (f) Assuming the price of gold is \$62.56 per gram, **calculate** the value of the gold that could be recovered from 1,000 metric tons of gold ore in the deposit. **Show** your work.
- (g) A typical cell phone contains 0.034 grams of gold. **Calculate** how many metric tons of gold ore would need to be mined to extract enough gold to manufacture 100,000 cell phones. **Show** your work.

Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.

STOP

END OF EXAM



ENVIRONMENTAL SCIENCE**SECTION II****Time—1 hour and 30 minutes****4 Questions**

Directions: Answer all four questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers on the pages following the questions in this book. Where calculations are required, clearly show how you arrived at your answer. Where explanation or discussion is required, support your answers with relevant information and/or specific examples.

1. Read the following article from the *Fremont Daily Times* and answer the questions that follow.

Fremont Daily Times**May 1, 2018****GREEN IS THE NEW SCHOOL COLOR AT FREMONT HIGH SCHOOL!**

A group of students from Fremont High School addressed the city council last night and proposed that one of the existing buildings at Fremont High School, which was built in 1970, be renovated to take advantage of recent advances in green technology. Currently the heat for the school is provided by fossil fuel combustion. The students said that the redesigned building would reduce the school's carbon footprint, which is a measure of the amount of carbon dioxide and other carbon compounds released by various human activities. Incorporating specific features that conserve energy and utilize

renewable energy sources can help reduce the carbon footprint.

Councilperson Gail Fassler praised the idea, saying that the project could conserve local water resources, reduce the need for consuming new resources, and act as a “shining beacon” of sustainability for the greater Fremont community. Fassler suggested the project could even incorporate a living green roof as an additional sustainable feature. The council approved the initial site planning request and urged students to report back when the project was under way.

- (a) The students want to reduce the school's carbon footprint.
- (i) **Define** carbon footprint.
 - (ii) **Identify** one way the school's heating system is likely adding to the school's carbon footprint.
 - (iii) **Describe** one realistic way to reduce the contribution of the heating system to the school's carbon footprint.
- (b) **Identify** TWO environmental benefits of a living green roof, such as that suggested by Councilperson Fassler.
- (c) **Describe** TWO practices the cafeteria's food service could use to decrease the environmental impacts of Fremont High School.
- (d) **Discuss** TWO benefits of using native plants for landscaping at Fremont High School.
- (e) During the renovation, the carpeting must be replaced. **Discuss** one environmental benefit of using flooring made of plant material, such as cork or bamboo, instead of carpet made of synthetic fibers.

ENVIRONMENTAL SCIENCE**SECTION II****Time—90 minutes****4 Questions**

Directions: Answer all four questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers on the pages following the questions in this book. Where calculations are required, clearly show how you arrived at your answer. Where explanation or discussion is required, support your answers with relevant information and/or specific examples.

1. Read the article below and answer the questions that follow.

The Fremont Plaindealer**May 1, 2013**

Last night the county council discussed a motion to support the construction of a new nuclear power plant on the Fremont River to address the rising demand for electrical power in Fremont County. Councilperson Pamela Kull spoke in support of the plant, remarking that “nuclear power plants produce no dangerous solid waste” and “using nuclear power avoids the release of

greenhouse gases.”

Councilperson Chinh Serach said that Dr. Kull’s remarks were incorrect and then introduced a different motion to provide funding to help Fremont homeowners and businesses reduce electricity use. He stated that such steps could make building the nuclear plant unnecessary.

- (a) State whether you agree or disagree with each of the following remarks made by Dr. Kull. For each remark, provide one justification for your position.
- (i) “Nuclear power plants produce no dangerous solid waste.”
 - (ii) “Using nuclear power avoids the release of greenhouse gases.”
- (b) If the plan for a nuclear power plant in Fremont is approved, it will take several years for the plant to be built. **Describe** TWO environmental problems that could result from the construction of the plant (i.e., prior to operation).
- (c) Suppose that the nuclear power plant is constructed on the Fremont River site.
- (i) **Identify** the most likely pollution threat that the plant will pose to the Fremont River as a result of the plant’s normal daily operation.
 - (ii) **Discuss** one potential ecological consequence of the pollution threat that you identified in part (i).
 - (iii) **Identify** a system often used in nuclear power plants to reduce the pollution you identified in part (i).
- (d) **Describe** TWO specific steps that Fremont residents and/or businesses could take to reduce the use of electricity.
- (e) **Identify** a specific nuclear power plant at which a major accident has occurred. **Explain** one environmental consequence (other than effects on human health) of a nuclear power plant accident.