

- 1 A sealed balloon contains air.

The temperature of the balloon is increased.

Which row describes how the pressure in the balloon and the kinetic energy of the particles in air change?

	pressure	kinetic energy of particles
A	decreases	decreases
B	increases	decreases
C	decreases	increases
D	increases	increases

- 3 The table shows information about four different particles.

particle	nucleon number	number of protons	number of neutrons	number of electrons
Na	23	11	W	11
Na ⁺	23	11	12	X
O	16	8	Y	8
O ²⁻	16	8	8	Z

What are the values of W, X, Y and Z?

	W	X	Y	Z
A	11	10	10	8
B	11	11	8	10
C	12	10	8	10
D	12	11	10	8

- 9 The molecular formulae of four compounds are listed.

1 CH₄

2 C₂H₆

3 C₃H₈

4 C₃H₆

Which molecular formulae are also the empirical formulae for the compounds?

- A** 1 and 2 **B** 1 and 3 **C** 2 and 4 **D** 3 and 4

- 3 A student makes crystals of the salt sodium sulfate, Na_2SO_4 . The student reacts 0.200 mol/dm^3 dilute sulfuric acid, $\text{H}_2\text{SO}_4(\text{aq})$, with aqueous sodium hydroxide, $\text{NaOH}(\text{aq})$.

The student uses the following steps.

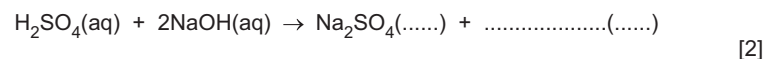
step 1 The student places 40.0 cm^3 of $\text{NaOH}(\text{aq})$ into a conical flask. This volume contains 0.0100 moles of NaOH .

step 2 The student adds a few drops of methyl orange indicator to the $\text{NaOH}(\text{aq})$ in the conical flask.

step 3 The student adds 0.200 mol/dm^3 $\text{H}_2\text{SO}_4(\text{aq})$ to the flask until the end-point is reached.

step 4 The student transfers the mixture from the conical flask to an evaporating basin and obtains dry crystals.

- (a) Complete the symbol equation for the reaction. Include state symbols.



- (b) State the type of exothermic reaction taking place.

..... [1]

- (c) Calculate the concentration of $\text{NaOH}(\text{aq})$ used in **step 1**.

concentration of $\text{NaOH}(\text{aq}) = \text{..... mol/dm}^3$ [1]

- (d) Name the item of apparatus the student uses to add $\text{H}_2\text{SO}_4(\text{aq})$ in **step 3**.

..... [1]

- (e) Calculate the volume of $\text{H}_2\text{SO}_4(\text{aq})$, in cm^3 , added in **step 3**.

volume of $\text{H}_2\text{SO}_4(\text{aq}) = \text{..... cm}^3$ [2]

- (f) State the colour change observed in **step 3**.

from to [2]

- (g) The dry crystals formed in **step 4** are coloured and **not** white. This is because the student should do an additional step between **step 3** and **step 4**.

Suggest what the student should do in this additional step to produce white crystals.

.....

..... [1]

- (h) In **step 4**, the student gently heats the solution in the evaporating basin until the solution is saturated. The student then stops heating and leaves the hot solution to cool. Crystals start to appear.

- (i) Explain the term saturated solution.

.....

.....

..... [2]

- (ii) Explain why crystals start to appear as the hot solution cools.

.....

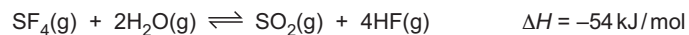
..... [1]

- (iii) Suggest the effect, if any, on the mass of crystals collected in **step 4** if the solution in the evaporating basin is allowed to dry without gentle heating.

..... [1]

[Total: 14]

4 Gaseous sulfur tetrafluoride, SF₄, reacts with steam in a reversible reaction.



(a) Complete the reaction pathway diagram in Fig. 4.1 for this reaction.

Include in your diagram:

- the position and the formulae of the products
- an arrow, labelled E_a , to show the activation energy
- an arrow, labelled ΔH , to show the enthalpy change of the reaction.

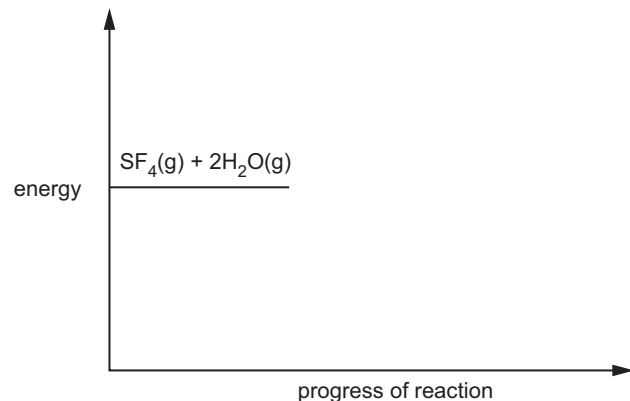


Fig. 4.1

[4]

(b) The equation for the reaction can be represented as shown in Fig. 4.2.

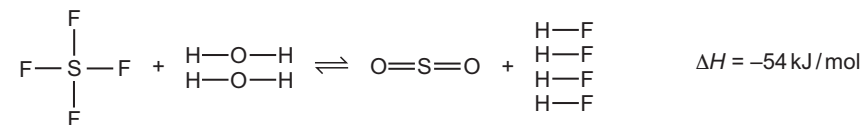


Fig. 4.2

Table 4.1 shows some bond energies.

Table 4.1

bond	S-F	O-H	H-F
bond energy in kJ/mol	330	460	570

Use the bond energies in Table 4.1 and the value of ΔH of the reaction to calculate the S=O bond energy in kJ/mol.

Use the following steps.

- Calculate the energy needed to break the bonds in the reactants.

..... kJ

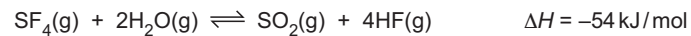
- Calculate the energy released when the bonds in the products form.

..... kJ

- Calculate the S=O bond energy.

..... kJ/mol
[4]

(c) The equation for the reaction is shown.



State the effect, if any, on the position of equilibrium when the following changes are made.

Give a reason for each of your answers.

- The temperature is increased.

.....
.....

- The pressure is increased.

.....
.....

- A catalyst is added.

.....
.....

[5]

(d) Explain, in terms of collision theory, why reducing the temperature decreases the rate of the reverse reaction.

.....
.....
.....
.....
..... [3]

[Total: 16]

Question 5 starts on the next page.

3 This question is about aluminium and other metallic elements.

- (a) Aluminium is extracted from purified bauxite by electrolysis. Fig. 3.1 shows a diagram of the electrolytic cell used.

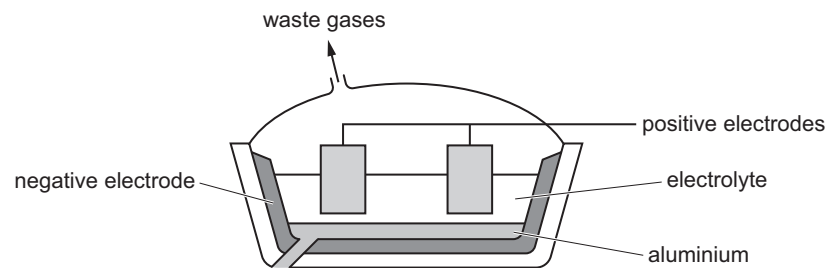
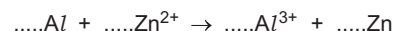


Fig. 3.1

- (i) State the name of the aluminium compound present in bauxite.
..... [1]
- (ii) Name the substance that purified bauxite is dissolved in before electrolysis is carried out.
..... [1]
- (iii) Name the substance that is used for the positive electrodes.
..... [1]
- (iv) Write the ionic half-equation for the production of aluminium at the negative electrode.
..... [2]
- (b) Aluminium is above zinc in the reactivity series.
- (i) When a piece of aluminium foil is added to aqueous zinc sulfate, a reaction is **not** immediately observed even though aluminium is above zinc in the reactivity series.
Explain why a reaction is **not** immediately observed.
..... [1]
- (ii) After a few minutes, a displacement reaction occurs between aluminium and aqueous zinc ions.
Complete the ionic equation for this reaction.



[1]

- (iii) State the oxidation number of zinc in:

Zn^{2+}

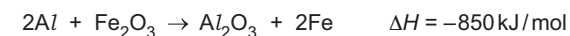
Zn.

[2]

- (iv) Define the term reduction in terms of oxidation number.

..... [1]

- (c) Aluminium reacts with iron(III) oxide. The equation is shown.



- (i) State the meaning of the symbol ΔH .

..... [1]

- (ii) State what can be deduced about the reaction from the negative sign in $\Delta H = -850 \text{ kJ/mol}$.

..... [1]

- (d) Gallium has many similarities to aluminium. Gallium(III) oxide is an amphoteric oxide.

State what is meant by the term amphoteric.

..... [1]

- (e) The reaction of gallium(III) oxide, Ga_2O_3 , with aqueous sodium hydroxide forms a salt which contains the negative ion GaO_2^- . The only other product is water.

Write a symbol equation for this reaction.

..... [2]

- (f) Deduce the formula of:

• gallium(III) bromide

• gallium(III) sulfate.

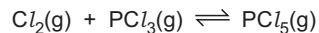
[2]

[Total: 17]

4 This question is about chlorine and compounds of chlorine.

- (a) Gaseous chlorine reacts with gaseous phosphorus(III) chloride to form gaseous phosphorus(V) chloride. The reaction is a reversible reaction.

When the three gases are in a closed container the system reaches equilibrium.



- (i) Describe a reversible reaction at equilibrium in terms of:

- the rate of the forward reaction and the rate of the reverse reaction

.....

- the concentrations of reactants and products.

.....

[2]

- (ii) Complete Table 4.1 using only the words **increases**, **decreases** or **no change**.

Table 4.1

change to condition	effect on the rate of the forward reaction	effect on the equilibrium concentration of PCl_5
the pressure is decreased		
a catalyst is added	increases	

[3]

- (iii) When the temperature of the equilibrium mixture is increased, the equilibrium concentration of PCl_5 decreases.

State what conclusion about the forward reaction can be made from this information.

..... [1]

- (b) Ethene, C_2H_4 , reacts with chlorine, Cl_2 , to form 1,2-dichloroethane, $\text{CH}_2\text{ClCH}_2\text{Cl}$.

The equation for this reaction can be represented as shown.

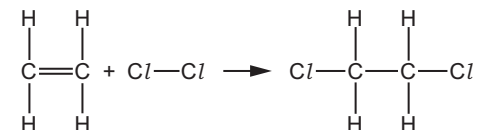


Table 4.2 shows some bond energies.

Table 4.2

bond	bond energy in kJ/mol
C—C	350
C=C	610
C—H	410
$\text{Cl}-\text{Cl}$	240
$\text{C}-\text{Cl}$	340

Use the bond energies in Table 4.2 to calculate the enthalpy change, in kJ/mol, of the reaction.

Use the following steps.

- Calculate the total energy needed to break the bonds in C_2H_4 and Cl_2 .

..... kJ

- Calculate the total energy released when the bonds form in $\text{CH}_2\text{ClCH}_2\text{Cl}$.

..... kJ

- Calculate the enthalpy change of the reaction.
Your answer should include a sign.

..... kJ/mol
[3]

- (c) Chlorine reacts with nitrogen to form nitrogen trichloride, NCl_3 .

Complete the dot-and-cross diagram in Fig. 4.1 of a molecule of NCl_3 .

Show outer shell electrons only.

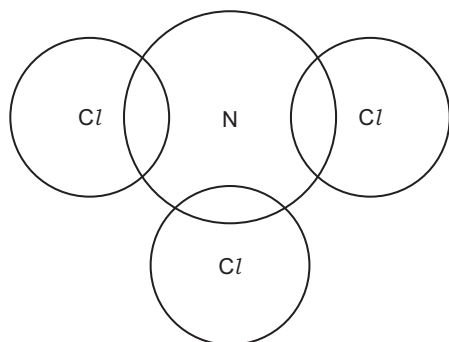


Fig. 4.1

[3]

- (d) When solid magnesium carbonate, MgCO_3 , is added to dilute hydrochloric acid, HCl , a chemical reaction occurs. The equation for the reaction is shown.



- (i) Give **two** observations when solid magnesium carbonate is added to dilute hydrochloric acid.

1

2

[2]

- (ii) Calculate the volume, in cm^3 , of $\text{CO}_2(\text{g})$ that is produced at room temperature and pressure (r.t.p.) when 50.0 cm^3 of $0.100 \text{ mol/dm}^3 \text{ HCl}$ reacts with excess MgCO_3 .

The volume of 1 mol of any gas is $24\,000 \text{ cm}^3$ at r.t.p.

Use the following steps.

- Calculate the number of moles of HCl in 50.0 cm^3 of $0.100 \text{ mol/dm}^3 \text{ HCl}$.

..... mol

- Deduce the number of moles of $\text{CO}_2(\text{g})$ produced.

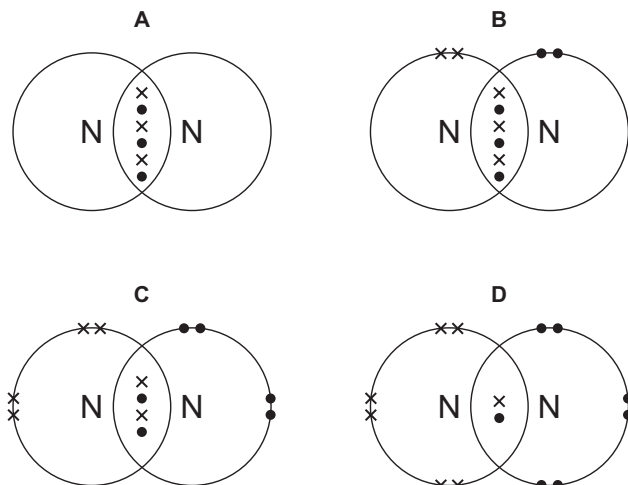
..... mol

- Calculate the volume, in cm^3 , of $\text{CO}_2(\text{g})$ produced at r.t.p.

..... cm^3
[3]

[Total: 17]

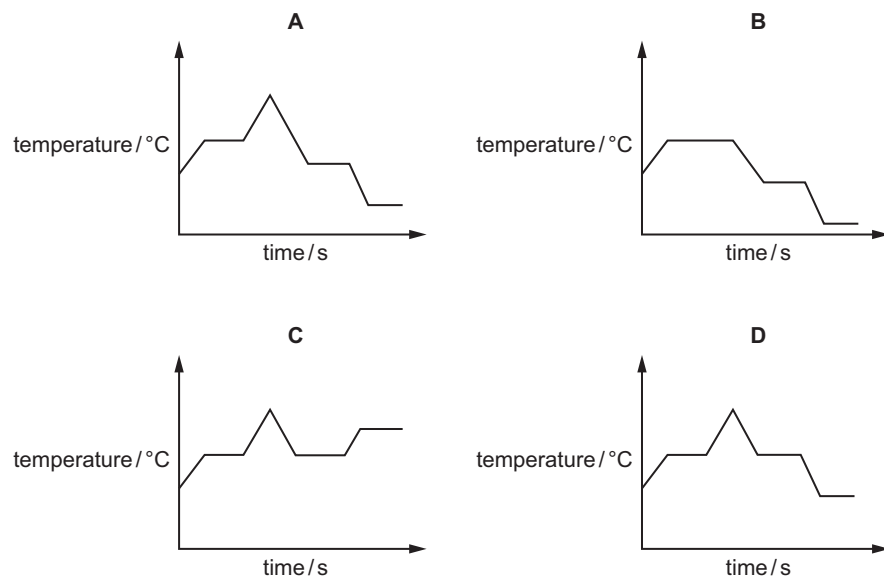
- 6 Which dot-and-cross diagram shows the outer shell electron arrangement in a molecule of nitrogen?



- 2 A sample of a liquid, X, is heated to a temperature above its boiling point.

X is then cooled, so that it condenses and then freezes.

Which graph describes the change in temperature of X over time?



- 1 Which two changes, when applied **at the same time** to a fixed amount of gas, cause the greatest increase in volume of the gas?

	change in pressure	change in temperature
A	decrease by 10%	decrease by 10%
B	increase by 10%	decrease by 10%
C	decrease by 20%	increase by 10%
D	increase by 20%	increase by 10%

- 3 Which atom has twice as many neutrons as protons?

A ${}^1_1\text{H}$ B ${}^2_1\text{H}$ C ${}^3_1\text{H}$ D ${}^4_2\text{He}$

- 4 What is the nucleon number of an atom?

- A the number of electrons, neutrons and protons in the nucleus
 B the number of neutrons and protons in the nucleus
 C the number of neutrons in the nucleus
 D the number of protons in the nucleus

- 9 Aqueous barium hydroxide, $\text{Ba}(\text{OH})_2$, reacts with dilute nitric acid, HNO_3 . The products are aqueous barium nitrate, $\text{Ba}(\text{NO}_3)_2$, and water.

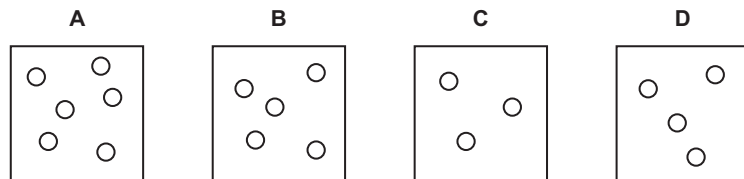
In a titration, 15.2 cm^3 of 0.75 mol/dm^3 aqueous barium hydroxide is required to neutralise 20.0 cm^3 of dilute nitric acid.

What is the concentration of the nitric acid?

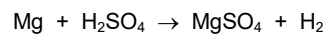
- A 0.29 mol/dm^3
 B 0.57 mol/dm^3
 C 1.14 mol/dm^3
 D 2.03 mol/dm^3

- 1 The diagrams show containers of gas at the same temperature. All containers have the same size.

Which container contains gas at the highest pressure?



- 10 The equation for the reaction of magnesium with dilute sulfuric acid is shown.



[M_r : MgSO_4 , 120]

Which mass of magnesium sulfate is formed when 12g of magnesium completely reacts with dilute sulfuric acid?

- A 5g B 10g C 60g D 120g

- 16 The reaction pathway diagram for the reaction between P and Q to form R and S is shown.

Which letter represents the enthalpy change for the reaction?

