Past-paper walk-through

Simple molecules and covalent bonds ▪ 2.5

eXercise

Questions in this set

- 0620/23 N25 Q7 ▪ 1 mark
- 0620/43 N25 Q4 ▪ 17 marks
- 0620/41 J25 Q4 ▪ 15 marks
- 0620/42 J25 Q2 ▪ 16 marks
- 0620/22 M25 Q7 ▪ 1 mark

Reading the mark scheme

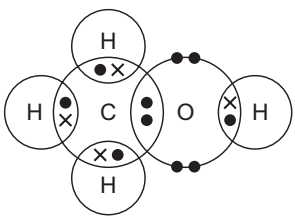
- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 7

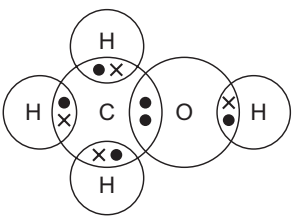
0620/23 N25 ▪ Q7 ▪ 1 mark

7 Which diagram shows the outer shell electron arrangement for a molecule of methanol, CH_3OH?

A



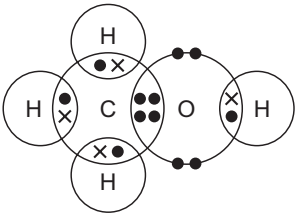
B

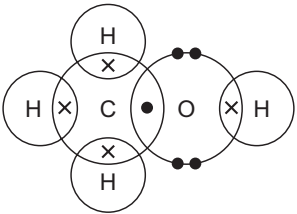


C

D

Question 7





Solution 7

Answer: **A**

Why

- Carbon needs four bonds, oxygen two, and each hydrogen one.
- In CH_3OH the carbon bonds to three hydrogens and to the oxygen; the oxygen bonds to that carbon and to one hydrogen.
- The oxygen also keeps two lone pairs, so check those are drawn.

Question 4

0620/43 N25 ▪ Q4 ▪ 17 marks

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.

$$Cl_2(g) + PCl_3(g) \rightleftharpoons PCl_5(g)$$

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

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

Question 4

- the concentrations of reactants and products.

Question 4

[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.

Question 4

Question 4

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

Question 4

(b) Ethene, C_2H_4, reacts with chlorine, Cl_2, to form 1,2-dichloroethane, CH_2ClCH_2Cl.

The equation for this reaction can be represented as shown.

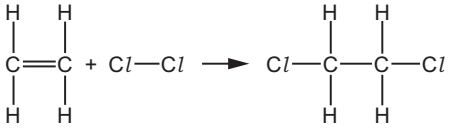


Table 4.2 shows some bond energies.

Table 4.2

bond	bond energy in kJ/mol
C–C	350

Question 4

Question 4

C=C	610
C–H	410
Cl–Cl	240
C–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.

Question 4

Question 4

..... kJ

- Calculate the total energy released when the bonds form in CH_2ClCH_2Cl.

..... kJ

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

Question 4

Question 4

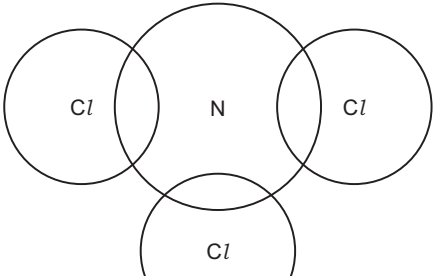
Question 4

[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.



Question 4

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Question 4

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.

$$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + CO_2(g) + H_2O(l)$$

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

Question 4

Question 4

[2]

(ii) Calculate the volume, in cm^3, of $CO_2(g)$ that is produced at room temperature and pressure (r.t.p.) when 50.0 cm^3 of 0.100 mol / dm^3 HC*l* reacts with excess $MgCO_3$.

The volume of 1 mol of any gas is 24 000 cm^3 at r.t.p.

Use the following steps.

- Calculate the number of moles of HC*l* in 50.0 cm^3 of 0.100 mol / dm^3 HC*l*.

..... mol

- Deduce the number of moles of $CO_2(g)$ produced.

Question 4

..... mol

- Calculate the volume, in cm^3, of $CO_2(g)$ produced at r.t.p.

Question 4

[3]

[Total: 17]

Solution 4

(a)(i)

Mark scheme

- ▪
- rates are equal
- ▪
- concentrations are no longer changing
- 2

Solution 4

(a)(ii)

Mark scheme

- M1 decreases M2
- decreases M3
- no change
- 3

Solution 4

(a)(iii)

Mark scheme

- forward reaction is exothermic
- 1
- 0620/43
- October/November 2025

Solution 4

(b) Mark scheme

- USUAL METHOD M1
- 2490 M2
- 2670 M3
- -180
- ALTERNATIVE METHOD M1
- 850 M2
- 1030 M3
- -180

Solution 4

- 3

Solution 4

(c)

Mark scheme

- M1 3 dot and cross bonding pairs M2
- one lone pair on the N atom (to complete the N octet) M3
- three lone pairs on each Cl atom (to complete each Cl octet)
- 3

Solution 4

(d)(i)

Mark scheme

- M1 solid disappears **M2**
- effervescence/bubbling/fizzing
- 2

Solution 4

(d)(ii)

Mark scheme

- M1 $0.005 \div 5 \times$ 10-3 (mol) M2
- $0.0025 \div 2.5 \times$ 10-3 (mol) M3
- 60 (cm3)
- 3
- 0620/43
- October/November 2025

Question 4

0620/41 J25 ▪ Q4 ▪ 15 marks

4 This question is about nitrogen and its compounds.

Nitrogen contains molecules with the formula N_2.

(a) Complete the dot-and-cross diagram in Fig. 4.1 to show the electronic configuration in a nitrogen molecule. Show outer-shell electrons only.

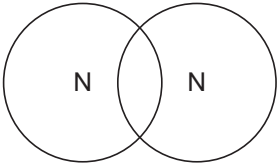


Fig. 4.1

[2]

Question 4

(b) Ammonia, NH_3, is manufactured by reacting nitrogen with hydrogen, H_2, in the Haber process.

(i) State **three** typical conditions for the reaction between nitrogen and hydrogen in the Haber process.

Question 4

Question 4

Question 4

[3]

(ii) Write the symbol equation for the chemical reaction in the Haber process.

Question 4

(c) Ammonia is converted into nitric acid in a two-step process.

In step 1, ammonia and oxygen are passed over a catalyst.

(i) Balance the symbol equation for this reaction.

$$4NH_3 + ...O_2 \rightleftharpoons .....NO + ...H_2O$$

[1]

(ii) Give the oxidation number of nitrogen in:

Question 4

Question 4

[2]

(iii) Define oxidation in terms of oxidation number.

Question 4

(iv) In step 2, oxygen and water react with NO to produce nitric acid as the only product.

Write a symbol equation for this chemical reaction.

Question 4

(d) Ammonia is converted into ammonium sulfate, $(NH_4)_2SO_4$.

$$2NH_3(g) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(s)$$

360 dm^3 of ammonia gas, measured at r.t.p., reacts with excess sulfuric acid.

Calculate the mass of ammonium sulfate produced, using the following steps.

- Calculate the number of moles of $NH_3(g)$ in 360 dm^3.

  One mole of any gas occupies 24 dm^3 at r.t.p.

Question 4

- Calculate the number of moles of $(NH_4)_2SO_4$ produced.

Question 4

- Calculate the mass of $(NH_4)_2SO_4$ produced.

  The M_r of $(NH_4)_2SO_4$ is 132.

Question 4

[3]

[Total: 15]

Solution 4

(a)

Mark scheme

- M1 3 dots and 3 crosses shared M2
- one non-bonding pair of 2 dots on one N atom and 2 crosses on the other N atom to complete the octet on both
- 2
- 0620/41
- May/June 2025

Solution 4

(b)(i)

Mark scheme

- Conditions can be in any order M1
- (temperature) 450 and °C
- M2(pressure)
- 200 and atmospheres / 20 000 and kPa M3
- iron and catalyst
- 3

Solution 4

(b)(ii)

Mark scheme

- $N2 + 3H2 \rightleftharpoons 2NH3$
- 1

Solution 4

(c)(i)

Mark scheme

- $5O2 \rightarrow 4NO + 6H2O$
- 1

Solution 4

(c)(ii)

Mark scheme

- M1 –3 M2
- +2
- 2

Solution 4

(c)(iii)

Mark scheme

- increase in oxidation number
- 1

Solution 4

(c)(iv)

Mark scheme

- $4NO + 3O2 + 2H2O \rightarrow 4HNO3$ M1
- $HNO3(1)$ M2
- equation completely correct
- 2

Solution 4

(d)

Mark scheme

- M1 15 M2
- 7.5 M3
- 990
- 3
- 0620/41
- May/June 2025

Question 2

0620/42 J25 ▪ Q2 ▪ 16 marks

2 This question is about covalent compounds.

(a) State what is meant by a covalent bond.

Question 2

(b) Chlorine(I) oxide, Cl_2O, is a simple molecule with covalent bonds.

(i) State what is meant by (I) in the name chlorine(I) oxide.

Question 2

(ii) Complete the dot-and-cross diagram in Fig. 2.1 of a molecule of chlorine(I) oxide.

Show outer electrons only.

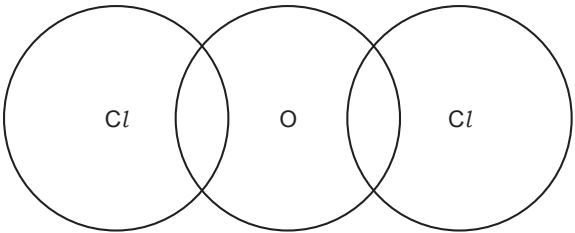


Fig. 2.1

[3]

Question 2

(iii) Explain, in terms of structure and bonding, why Cl_2O boils at a low temperature and does **not** thermally decompose into its constituent elements, Cl_2 and O_2.

Question 2

(iv) Give **two** reasons why liquid Cl_2O is a poor conductor of electricity.

Question 2

[2]

(c) Carbon and silicon(IV) oxide both exist as giant covalent structures.

(i) Name a giant covalent structure of carbon which conducts electricity.

Question 2

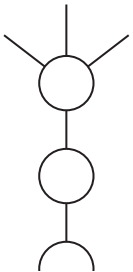
(ii) Identify the particles responsible for the conduction of electricity in this covalent structure of carbon.

Question 2

(iii) Silicon(IV) oxide contains silicon atoms, Si, and oxygen atoms, O.

Fig. 2.2 shows part of the giant covalent structure of silicon(IV) oxide.

Complete the diagram in Fig. 2.2 by adding the symbol for each of the 9 atoms shown.



Question 2

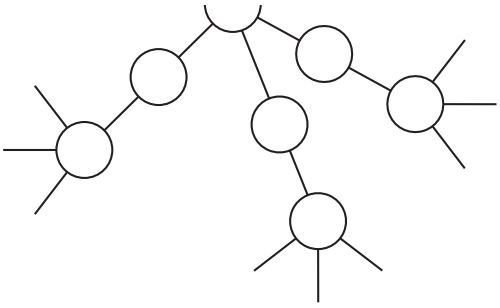


Fig. 2.2

[2]

Question 2

[Total: 16]

Solution 2

(a)

Mark scheme

- M1 pair of electrons **M2**
- electron(s) shared between two atoms
- 2

Solution 2

(b)(i)

Mark scheme

- M1 the oxidation number of chlorine / Cl M2
- (oxidation number) is +1
- 2

Solution 2

(b)(ii)

Mark scheme

- M1 O with 1 dot-cross bonding pair with each Cl **M2**
- 4 non-bonding dots for O **M3**
- 6 non-bonding crosses for each Cl
- 3

Solution 2

(b)(iii)

Mark scheme

- M1 (forces of) attraction between molecules are broken (during boiling) M2
- covalent bonds (between Cl and O atoms) are broken (during thermal decomposition) M3
- weak attraction between molecules and strong covalent bonds / bonding between atoms correctly applied
- 3

Solution 2

(b)(iv)

Mark scheme

- M1 no ions **M2**
- no mobile electrons
- 2

Solution 2

(c)(i)

Mark scheme

- graphite
- 1

(c)(ii)

Mark scheme

- electrons
- 1

Solution 2

(c)(iii)

Mark scheme

- M1 5 correct Si atoms M2
- 4 correct O atoms
- 2
- 0620/42
- May/June 2025

Question 7

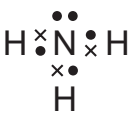
0620/22 M25 ▪ Q7 ▪ 1 mark

7 For which covalent compound does the dot-and-cross diagram correctly show the outer shell electrons?

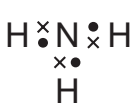
A

B

C



D



Solution 7

Answer: **C**

Why

- Each shared pair must sit between the two atoms, drawn as one dot and one cross.
- Hydrogen needs exactly two electrons in its shell; chlorine and nitrogen need eight.
- So check every atom ends with a complete outer shell and no shared pair is counted twice.