Cambridge Assessment International Education

Specimen Paper Answers

Paper 2: Theory

Cambridge O Level Chemistry

5070

For examination from 2023

Version 1

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Contents

Introduction

The main aim of this booklet is to exemplify standards for those teaching Cambridge O Level Chemistry 5070, and to show examples of very good answers.

In this booklet, we have provided answers for all questions with examiner comments. These exercises require candidates to answer short-answer and structured questions and candidates are awarded maximum of 80 marks for this paper and the mark scheme provides the answers required to gain the marks.

Each question and answer is followed by an examiner comment on the candidates answer. Additionally, the examiner has set out a number of common mistakes that occur when candidates answer the questions. In this way, it is possible to understand what candidates have done to gain their marks and how they could improve their answers and avoid errors.

The mark schemes for the Specimen Papers are available to download from the School Support Hub at **www.cambridgeinternational.org./support**

2023 Specimen Paper 2 Mark Scheme

Past exam resources and other teaching and learning resources are available on the School Support Hub www.cambridgeinternational.org/support

Assessment at a glance

The syllabus for Cambridge O Level Chemistry 5070 is available at www.cambridgeinternational.org

All candidates take three papers. Candidates will be eligible for grades A* to E.

Paper 1: Multiple Choice			Paper 2: Theory	
1 hour 40 Marks 40 four-option multiple-choice questions Externally assessed	30%	**And**	1 hour 45 minutes 80 Marks Short-answer and structured questions Externally assessed	50%

Practical assessment

Paper 3: Practical Test			Paper 4: Alternative to Practical	
1 hour 30 minutes 40 Marks Questions will be based on the experimental skills in Section 4 Externally assessed	20%	**Or**	1 hour 40 Marks Questions will be based on the experimental skills in Section 4 Externally assessed	20%

Question 1

Question 1(a)

1 Choose from the list of oxides to answer the questions.

calcium oxide

carbon dioxide

copper(II) oxide

silicon(IV) oxide

sodium oxide

sulfur dioxide

sulfur trioxide

zinc oxide

Each oxide can be used once, more than once or not at all.

Identify which oxide:

(a) has a giant covalent structure

silicon (IV) oxide ✓ [1]

Mark awarded = 1 out of 1

Examiner comment

This question requires the candidate to recall the structure of silicon (IV) oxide.

Common mistakes

Zinc oxide

Question 1(b)

(b) reacts with both acids and alkalis,

zinc oxide ✓ [1]

Mark awarded = 1 out of 1

Examiner comment

Candidates need to recall that zinc oxide is amphoteric; it is not on the extreme right or extreme left of the Periodic Table.

Question 1(c)

(c) is used in flue gas desulfurisation

calcium oxide ✓ [1]

Mark awarded = 1 out of 1

Examiner comment

This question requires candidates to recall that flue gas desulfurisation is carried out using calcium oxide.

Common mistakes

Sodium oxide – candidates might recall that a metal oxide is used to react with acidic gases in flue gas desulfurisation, but incorrectly state sodium oxide.

Question 1(d)

(d) contains a cation with a charge of +1.

sodium oxide ✓ [1]

Mark awarded = 1 out of 1

Examiner comment

Candidates must use their knowledge of the formation of cations and anions, and the relationship between group number in the Periodic Table and the charge of ions formed by elements in that group, to determine that a Group I metal oxide is required.

Total mark awarded = 4 out of 4

Question 2

Question 2(a)

2 Atoms and ions contain protons, neutrons and electrons.

(a) Complete Table 2.1.

Table 2.1

	relative charge	relative mass
proton	+1	1 ✓
neutron	0 ✓	1
electron	-1 ✓	1/1860 ✓

[3]

Mark awarded = 3 out of 3

Examiner comment

The question requires candidates to recall the relative charges and relative masses of a proton, neutron and an electron.

Question 2(b)(i)

(b) Table 2.2 shows some information about six particles.

Table 2.2 **New screenshot required**

particle	number of protons	number of neutrons	number of electrons
A	37	48	37
B	53	74	54
C	92	143	92
D	92	143	89
E	92	146	92
F	94	150	92

(i) Deduce the nucleon number for particle **A**.

85 ✓ ..... [1]

Mark awarded = 1 out of 1

Examiner comment

Candidates recall that the nucleon number is the total number of protons and electrons in the nucleus of an atom: protons + neutrons = 37 + 48 = 85

Question 2(b)(ii)

(ii) Explain why particle **B** is a negative ion.

Contains more electrons, which are negatively charged, than protons, which are positively charged ✓ [1]

Mark awarded = 1 out of 1

Examiner comment

Stating 'more electrons than protons' is sufficient to gain the mark.

Question 2(b)(iii)

(iii) Identify two **atoms** that are isotopes of the same element.

C ✓ and *E ✓*

Explain your answer.

They have the same number of protons but a different number of neutrons.✓

[2]

Mark awarded = 2 out of 2

Examiner comment

Candidates must recall that isotopes are different atoms of the same elements that have the same number of protons but different number of neutrons, and then apply this to the particles in Table 2.2.

Common mistakes

Some candidates make the following incorrect assumptions about isotopes of the same element:

- They have the same number of protons and neutrons and a different number of electrons (in this example, this would lead candidates to an answer of **C** and **D**).
- They have the same number of neutrons and a different number of protons (there is not an example of this in the given table).

Total mark awarded = 7 out of 7

Question 3

Question 3(a)

3 Salts can be prepared by the reaction of acids with bases or alkalis and also by precipitation reactions.

(a) State the ionic equation for the reaction between an acid and an alkali.

$H^+ + OH^- \rightarrow H_2O$ ✓ ..... [1]

Mark awarded = 1 out of 1

Examiner comment

This question requires candidates to recall the neutralisation reaction between an acid and an alkali to produce water.

Question 3(b)

(b) Sodium sulfate is a soluble salt prepared by a titration method using an acid and an alkali.

Identify the acid and the alkali used to prepare sodium sulfate.

acid sulfuric acid ✓

alkali sodium hydroxide ✓

[1]

Mark awarded = 1 out of 1

Examiner comment

The candidate must recall the preparation of soluble salts by reaction of an acid with an alkali by titration.

Common mistakes

Candidates often incorrectly suggest sodium oxide, which itself cannot be titrated because when in solution (titrations require a solution) it forms sodium hydroxide.

Question 3(c)(i)

(c) Aqueous sodium sulfate is used to prepare barium sulfate in a precipitation reaction.

$$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$$

In an experiment 20.0 cm^3 of 0.550 mol/dm^3 of barium nitrate is added to an excess of sodium sulfate.

(i) State the colour of the precipitate formed in the reaction.

white ..... [1]

Mark awarded = 1 out of 1

Examiner comment

The candidate must recall the test for sulfate from the *Notes for use in qualitative analysis*. Some candidates might also recognise that barium is not a transition element so not likely to be coloured.

Question 3(c)(ii)

(ii) Calculate the maximum mass of barium sulfate that could be made.

[M_r: $BaSO_4$, 233]

Show your working.

No. moles Ba^{2+} = (0.020 × 0.550) ÷ 1000 = 0.011 mol ✓

mass 0.011 mol $BaSO_4$ = 0.011 × 233 = 2.563

maximum mass of barium sulfate = ... 2.563 ✓ ..... g [2]

Mark awarded = 2 out of 2

Examiner comment

Candidates must show their working in order to be awarded the mark for a correct intermediate calculation, as well as a mark for the correct final answer:

Number of moles of barium nitrate = (volume × concentration) ÷ 1000; substituting in the values for volume and concentration given in the question, remembering to convert the volume from cm^3 to dm^3, is awarded one mark.

The candidate uses the fact that the number of moles of barium nitrate = number of moles of Ba^{2+} = number of moles of $BaSO_4$ to calculate the stoichiometric reacting mass of $BaSO_4$.

The mass $BaSO_4$ = number of moles $BaSO_4$ × M_r
= 0.011 × 233 = 2.563

Common mistakes

Candidates often forget to divide by 1000, giving them an incorrect final answer of 2563 g.

Question 3(c)(iii)

(iii) A mass of 1.92 g of dry barium sulfate is obtained.

Calculate the percentage yield of barium sulfate.

$(1.92 \div 2.563) \times 100 =$ ✓

percentage yield of barium sulfate = 74.9 ✓ % [1]

Mark awarded = 1 out of 1

Examiner comment

The candidate uses (yield ÷ theoretical yield) × 100

Common mistakes

Candidates often invert the division (theoretical yield ÷ yield), resulting in an incorrect answer of 133.5 %.

Total mark awarded = 6 out of 6

Question 4

Question 4(a)

4 Calcium chloride, $CaCl_2$, is an ionic compound.

(a) Deduce the electronic configuration for each of the ions in calcium chloride.

calcium ion 2.8.8 ✓

chloride ion 2.8.8 ✓

[2]

Mark awarded = 2 out of 2

Examiner comment

Candidates can use their knowledge of the formation of ionic bonds and refer to the Periodic Table to work out the noble gas electronic configuration for each ion.

Question 4(b)

(b) When **molten** calcium chloride is electrolysed with inert electrodes, calcium and chlorine are formed.

Construct ionic half-equations for the two electrode reactions.

reaction at the negative electrode

$Ca^{2+} + 2e^- \rightarrow Ca$ ✓

reaction at the positive electrode

$2Cl_2 \rightarrow Cl_2 + 2e^-$ ✓

[2]

Mark awarded = 2 out of 2

Examiner comment

The reaction at the cathode should show reduction: the ion is Ca^{2+} and this gains electrons.
The reaction at the anode should show oxidation: the ions are Cl^- and each lose an electron.
Chlorine is diatomic Cl_2.

Common mistakes

Common mistakes candidates make when writing the required ionic half-equations are:

- $Ca \rightarrow Ca^{2+} + 2e^-$
- $Cl^- \rightarrow Cl + e^-$
- $Cl^- \rightarrow Cl_2 + 2e^-$

Question 4(c)

(c) The electrolysis of concentrated aqueous calcium chloride with inert electrodes is similar to that of concentrated aqueous sodium chloride.

Predict the products of the electrolysis of concentrated **aqueous** calcium chloride with inert electrodes.

chlorine, hydrogen and calcium hydroxide ✓ [1]

Mark awarded = 1 out of 1

Examiner comment

Candidates need to recall the products of the electrolysis of concentrated aqueous sodium chloride as chorine, hydrogen and sodium hydroxide, then apply this to calcium chloride.

Common mistakes

Some candidates will predict that calcium and/or oxygen are products.

Question 4(d)

(d) Calcium chloride has a high melting point.

Explain why calcium chloride has a high melting point. Use ideas about structure and bonding.

Calcium chloride has a giant ionic lattice ✓ with very strong attraction between the oppositely charged ions of Ca^{2+} and Cl^- in the extensive network, which takes a large amount of energy to separate the ions, hence the high melting point ✓

[2]

Mark awarded = 2 out of 2

Examiner comment

Candidates are told that calcium chloride is an ionic compound in the question stem. So, this question can be answered using recall of why the melting point of ionic compounds is high in terms of their structure and bonding.

Common mistakes

Candidates often use the term ‘ionic’ but with no reference to a giant lattice.

Some candidates will state there is a strong ionic bond rather than explaining what the strong ionic bond is, i.e. between positive and negative ions.

Total mark awarded = 7 out of 7

Question 5

Question 5(a)

5 Figure 5.1 shows the alcohols ethanol and butan-1-ol.

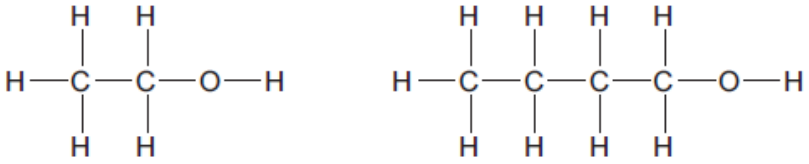


Fig. 5.1

(a) Describe the manufacture of ethanol from ethene.

React ethene with steam ✓ at 300 °C and 6000 kPa in the presence of an acid catalyst, ✓ often silicon dioxide coated with phosphoric(V) acid. [2]

Mark awarded = 2 out of 2

Examiner comment

The candidate must recall the manufacture of ethanol by the catalytic addition of steam to ethene. The candidate has given more information than is required by giving a specific catalyst.

Common mistakes

Candidates will often forget the presence of the acid catalyst.

Question 5(b)(i)

(b) Ethanol is used as a fuel.

(i) State one **other** use of ethanol.

Solvent ✓ [1]

Mark awarded = 1 out of 1

Examiner comment

This requires simple recall of the uses of ethanol as a solvent and a fuel. Candidates could also recall that the oxidation of ethanol produces vinegar and therefore correctly state ‘making vinegar’ as one other use of ethanol.

Question 5(b)(ii)

(ii) Construct a symbol equation to show the **incomplete** combustion of ethanol.

$C_2H_5OH + 2O_2 \rightarrow 2CO + 3H_2O$ ✓ [2]

Mark awarded = 2 out of 2

Examiner comment

Candidates must recall the formula of ethanol, that the combustion of alcohols is a reaction with oxygen, and that incomplete combustion forms carbon monoxide and/or carbon and water, and then apply all of this to the incomplete combustion of ethanol. Then, they must balance the equation correctly.

Common mistakes

A common mistake is to forget to balance the equation.

Question 5(c)

(c) Ethanol is oxidised to form ethanoic acid.

State the name of a reagent that is used for this oxidation.

acidified aqueous potassium manganate(VII) ✓ [1]

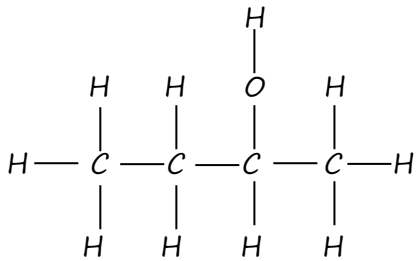
Mark awarded = 1 out of 1

Examiner comment

This question requires recall of the formation of ethanoic acid by the oxidation of ethanol. 'Oxygen' is also a correct alternative answer.

Question 5(d)

(d) Draw the displayed formula of a **different** alcohol that is an isomer of butan-1-ol.



[1]

Mark awarded = 1 out of 1

Examiner comment

There are three isomers (same molecular formula different arrangement of atoms) of butan-1-ol. The candidate has drawn one of them with all of the atoms and all of the bonds.

Common mistakes

A common mistake is candidates do not include the O-H bond in the alcohol.

Question 5(e)(i)

(e) Butan-1-ol is heated with concentrated sulfuric acid which acts as a catalyst.

But-1-ene and one other compound are formed.

(i) Draw the structural formula of but-1-ene.

$CH_3CH_2CH=CH_2$ ✓

[1]

Mark awarded = 1 out of 1

Examiner comment

This question requires recall of the structural formula of but-1-ene.

Common mistakes

Some candidates draw but-2-ene by mistake.

Question 5(e)(ii)

(ii) Deduce the **other** compound formed in the reaction.

Water ✓ [1]

Mark awarded = 1 out of 1

Examiner comment

Candidates should deduce that as the OH and the adjacent H are removed from butan-1-ol to form a double bond between the first two carbons when but-1-ene is formed, the other product is water (H_2O). Some candidates might recognise this as an elimination reaction, and recall that water is produced.

Common mistakes

Candidates often forget the O and incorrectly deduce that hydrogen is the other compound formed.

Question 5(f)(i)

(f) But-2-ene, $CH_3CH=CHCH_3$, is polymerised to give poly(but-2-ene).

(i) State the type of polymerisation that occurs.

Addition ✓ [1]

Mark awarded = 1 out of 1

Examiner comment

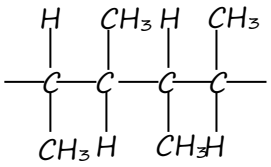
Candidates must recall that when the monomer has a double bond, the polymerisation is addition.

Common mistakes

Candidates often confuse addition and condensation polymerisations.

Question 5(f)(ii)

(ii) Draw the structure of poly(but-2-ene) showing at least one repeat unit.



[2]

Mark awarded = 2 out of 2

Examiner comment

The candidate draws two correct repeat units with no double bond (a minimum of one repeat unit is required); they have included free bonds at either end.

Common mistakes

Candidates often do not show a whole number of repeat units. When candidates draw more than one repeat unit this can lead to errors.

Total mark awarded = 12 out of 12

Question 6

Question 6(a)

6 A mixture of ethanoic acid, ethene and oxygen is passed over a catalyst at 200 °C to manufacture ethenyl ethanoate, $CH_3COOCH=CH_2$.

$$CH_3COOH + CH_2=CH_2 + \tfrac{1}{2}O_2 \rightarrow CH_3COOCH=CH_2 + H_2O$$

The reaction is exothermic.

(a) Draw a reaction pathway diagram for this reaction on Fig. 6.1.

On your diagram label:

- the axes
- the reactants and products
- the enthalpy change of the reaction, ΔH
- the activation energy, E_a.

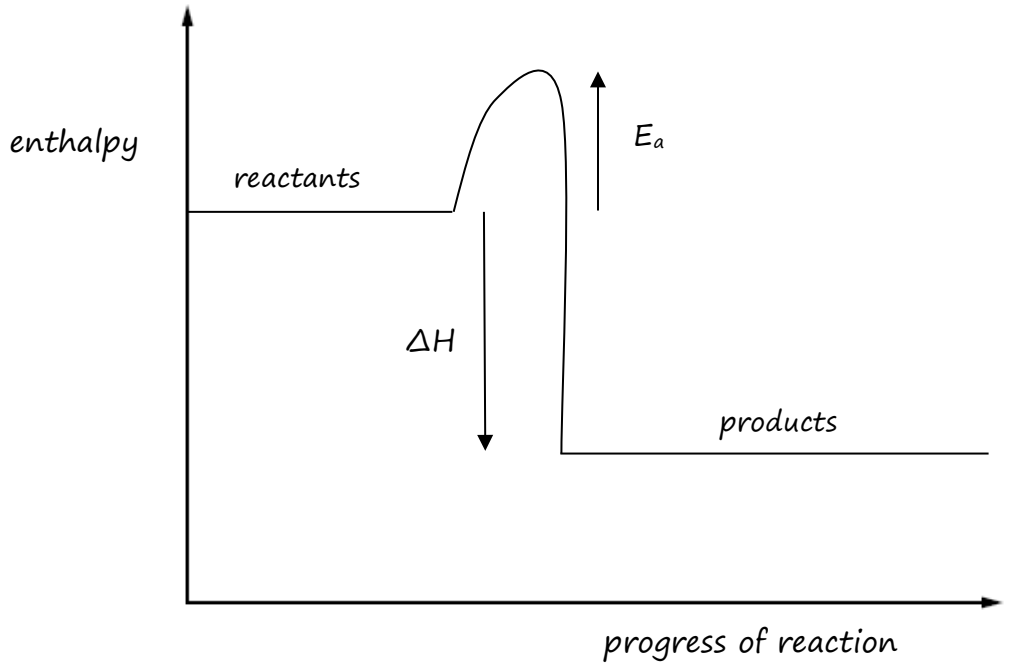


Fig. 6.1 [4]

Mark awarded = 4 out of 4

Examiner comment

This question requires recall of a reaction pathway diagram for an exothermic reaction. The candidate has correctly met each of the requirements in the bulleted list: the axes show enthalpy and progress of reaction; they have labelled the reactants and products and also shown that the reaction is exothermic (product energy is lower than reactant energy); the ΔH is labelled and shown by the downwards arrow from reactants to products; and E_a is labelled and shown by the upwards arrow from reactants to the top of the 'hump', i.e. above the highest energy level of both products and reactants.

Common mistakes

Some common mistakes that candidates make include:

- *x*-axis label missing
- an endothermic reaction is shown
- ΔH arrow is upwards or double headed or just a line
- E_a arrow is downwards.

Question 6(b)

(b) Explain why the enthalpy change of the reaction is exothermic.

Use ideas about bond breaking and bond making.

The energy involved in making the new bonds is greater ✓ than the energy used to break the original bonds. ✓ [2]

Mark awarded = 2 out of 2

Examiner comment

The candidate is told that the reaction is exothermic, so they must recall that bond breaking is endothermic (energy taken in), and the bond making is exothermic (energy given out), and understand that if the overall reaction is exothermic, it means the energy given out is greater than the energy taken in.

Common mistakes

- the energy used to break the bonds is less than the energy used to make the bonds (i.e. the candidate is saying that both processes are endothermic)
- the energy given out to make the bonds is more than the energy given out to break the bonds (i.e. the candidate is saying that both processes are exothermic)

Total mark awarded = 6 out of 6

Question 7

Question 7(a)

7 Peroxodisulfate ions, $S_2O_8^{2-}$, react with iodide ions in aqueous solution.

$$S_2O_8^{2-}(aq) + 2I^-(aq) \rightarrow 2SO_4^{2-}(aq) + I_2(aq)$$

(a) Iodide ions are oxidised in this reaction.

State how the equation shows this.

Each I^- is losing an electron to form I_2 molecules. ✓

..... [1]

Mark awarded = 1 out of 1

Examiner comment

Candidates must recall that oxidation is a loss of electrons and recall how to identify oxidation in a redox reaction. They should identify that $2I^-$ loses an electron each to give one I_2 molecule.

Question 7(b)

(b) Table 7.1 shows how the relative rate of this reaction changes when different concentrations of peroxodisulfate ions and iodide ions are used.

Table 7.1

experiment	concentration of $S_2O_8^{2-}$ in mol / dm^3	concentration of I^- in mol / dm^3	relative rate of reaction
1	0.008	0.02	1.7
2	0.016	0.02	3.3
3	0.032	0.02	6.8
4	0.008	0.04	3.4
5	0.008	0.08	6.9

Using the information in Table 7.1, describe how **increasing** the concentration of each of these ions affects the relative rate of reaction.

peroxodisulfate ions

Doubling the concentration of peroxodisulfate ions doubles the rate. ✓

.....

iodide ions

Doubling the concentration of I^- ions doubles the rate. ✓

.....

[2]

Mark awarded = 2 out of 2

Examiner comment

This question requires candidates to interpret data from rate of reaction experiments.

For peroxodisulfate ions, the candidate must use the experiments where the concentration of iodide ions is constant and the concentration of peroxodisulfate ions increases, and look at the corresponding rates of reaction. They should see that as the concentration of peroxodisulfate ions increases, so does the rate of reaction. Some candidates might look at experiments 1 and 2 (or 2 and 3) and see that as the concentration of peroxodisulfate ions doubles, the rate of reaction also doubles (within experimental error).

For iodide ions, candidates must look at experiments where the concentration of peroxodisulfate ions is constant and the concentration of iodide ions increases, and look at the corresponding rates of reaction. Again, they will see that as the concentration of iodide ions increases so does the rate of reaction. Some candidates might spot that as the concentration of iodide ions doubles (experiment 1 and 4, or 4 and 5) and so does the rate of reaction (within experimental error).

Common mistakes

A common mistake candidates make is that they don't select experiments where the concentration of iodide ions is constant in order to determine the effect of peroxydisulfate ion concentration, and the concentration of peroxydisulfate ions is constant to determine the effect of iodide ion concentration.

Question 7(c)

(c) Iron(III) ions, Fe^{3+}, catalyse this reaction.

Explain how catalysts increase the rate of a reaction.

They provide an alternative route with a lower activation energy ✓ so that more particles have energy greater than the activation energy and hence more collisions are successful. ✓ [2]

Mark awarded = 2 out of 2

Examiner comment

The candidate must recall the effect on the rate of reaction of adding a catalyst.

Common mistakes

Some candidates will talk about an increased activation energy.

Some candidates will mention more frequent collisions, but not mention that they are successful.

Total mark awarded = 5 out of 5

Question 8

Question 8(a)

8 Copper reacts with concentrated nitric acid to form copper(II) nitrate.

$$Cu(s) + 4HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l)$$

(a) State the meaning of (aq).

aqueous, dissolved in water ✓

..... [1]

Mark awarded = 1 out of 1

Examiner comment

This question requires recall of the state symbol (aq) and what it means.

Common mistakes

Candidates will often mistake (aq) for meaning 'soluble in water', rather than a 'solution in water'.

Question 8(b)

(b) An excess of copper is added to 25.0 cm^3 of 16.0 mol / dm^3 HNO_3.

Use this information, together with the equation, to calculate the volume of NO_2 formed. The gas volume is measured at room temperature and pressure.

Show your working and state the units.

number of moles HNO_3 = (25 × 16) ÷ 1000 = 0.40 mol ✓

number of moles NO_2 is half number of moles of HNO_3 = 0.20 mol ✓

volume = 0.2 × 24 = 4.8

volume of NO_2 = 4.8 dm^3 ✓ [3]

Mark awarded = 3 out of 3

Examiner comment

This question requires candidates to do a calculation. They must show their working in order to get intermediate marks as well as a mark for the correct final answer.

Number of moles HNO_3 = (25 × 16) ÷ 1000 = 0.40 mol

Using the equation, no. of moles of NO_2 is half number of moles of HNO_3 = 0.20 mol

Using the molar gas volume as given on the Periodic Table, volume = 0.2 × 24 = 4.8 dm^3

Common mistakes

A common mistake candidates make is to forget the stoichiometry and miss the step of dividing by two, so here would calculate a final answer of 9.6 dm^3.

Candidates also use the incorrect unit when writing their final answer, e.g. 4.8 cm^3 or 4800 dm^3.

Question 8(c)

(c) When heated, $Cu(NO_3)_2$ decomposes to form CuO, NO_2 and O_2.

Construct the symbol equation for this reaction.

$2Cu(NO_3)_2 \rightarrow 2CuO + 4NO_2 + O_2$ ✓ [1]

Mark awarded = 1 out of 1

Examiner comment

Candidates must recall how to construct symbol equations and apply this to the information given.

Common mistakes

Some candidates will incorrectly write copper nitrate as $CuNO_3$.

Another common mistake is to not balance the equation.

Question 8(d)(i)

(d) To a small sample of $Cu(NO_3)_2(aq)$, a student adds aqueous ammonia drop by drop until it is in excess.

(i) Describe what is observed.

Initially pale blue precipitate ✓ which dissolves in excess to form a dark blue solution. ✓ [2]

Mark awarded = 2 out of 2

Examiner comment

Candidates must recall the test for the copper(II) aqueous cation, that uses the effect of aqueous ammonia.

Common mistakes

Common mistakes that candidates make are to:

- mention the blue precipitate only, without going on to say what happens in excess aqueous ammonia
- state that the blue precipitate dissolves in excess to give a blue solution, without specifying that the solution is dark blue

Question 8(d)(ii)

(ii) The student repeats the experiment but adds aqueous sodium hydroxide instead of aqueous ammonia.

Describe what is observed.

Pale blue precipitate which does not dissolve in excess. ✓

..... [1]

Mark awarded = 1 out of 1

Examiner comment

Candidates must recall the test for the copper(II) aqueous cation, that uses the effect of aqueous sodium hydroxide.

Common mistakes

A common mistake is to confuse the result with that expected when aqueous ammonia is added, i.e. pale blue precipitate that dissolves in excess to form a dark blue solution.

Total mark awarded = 8 out of 8

Question 9

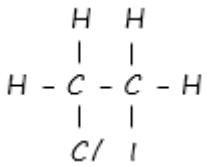
Question 9(a)

9 Iodine reacts with chlorine to form iodine(I) chloride, ICl.

(a) Iodine(I) chloride reacts in a similar way to bromine.

Iodine(I) chloride reacts with ethene in an addition reaction.

Draw the displayed formula of the product of this reaction.



[1]

Mark awarded = 1 out of 1

Examiner comment

The candidate must recall the addition reaction of ethene with bromine, and then apply this to a reaction with iodine(I) chloride.

Common mistakes

Candidates will often draw the Cl and I on the same C.

Question 9(b)(i)

(b) Iodine(I) chloride reacts in a similar way to chlorine.

Iodine(I) chloride reacts with ethane in a photochemical reaction in the presence of ultraviolet light.

(i) State the type of reaction that takes place.

free radical substitution. ✓ [1]

Mark awarded = 1 out of 1

Examiner comment

Candidates must recall the substitution reaction of alkanes with chlorine.

Common mistakes

Some candidates will incorrectly recall the reaction as an addition reaction.

Question 9(b)(ii)

(ii) Suggest a symbol equation for the reaction between iodine(I) chloride and ethane.

$C_2H_6 + ICl \rightarrow C_2H_5Cl + HI$ ✓ [1]

Mark awarded = 1 out of 1

Examiner comment

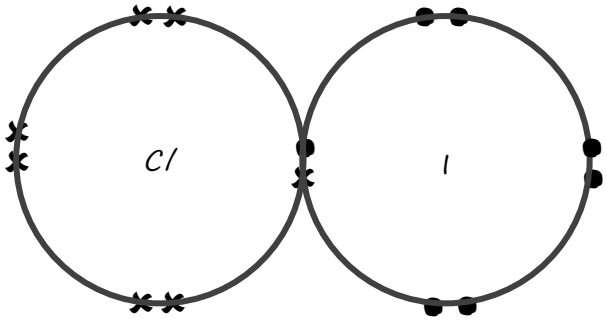
Candidates must recall the substitution reaction of alkanes with chlorine and apply this to iodine(I) chloride by substituting I*Cl* in place of C*l*.

Question 9(c)

(c) The dot-and-cross diagram for a molecule of iodine(I) chloride is similar to that for a molecule of chlorine.

Draw the dot-and-cross diagram for a molecule of iodine(I) chloride.

Show outer electrons only.



[1]

Mark awarded = 1 out of 1

Examiner comment

Candidates recall the dot-and-cross diagram for a molecule of chlorine (Cl_2) and apply it to the similar molecule, iodine(I) chloride.

Question 9(d)(i)

(d) Iodine(I) chloride reacts with chlorine to form iodine(III) chloride.

This reaction is investigated at 200 °C in a closed system.

The reversible reaction reaches an equilibrium.

$$ICl(g) + Cl_2(g) \rightleftharpoons ICl_3(g)$$

(i) Describe **two** features of a reversible reaction at equilibrium, in a closed system.

In your answer, refer to the rate of reaction and to the concentrations of reactants and product.

The rate of the forward and backwards reactions are the same.

The concentrations of the reactants and the products do not change ✓

[2]

Mark awarded = 2 out of 2

Examiner comment

The candidate must recall what indicates that a reversible reaction in a closed system is in equilibrium.

Common mistakes

Some candidates state that the concentration of the reactants is the same as the concentration of the products, confusing the fact that the concentrations stay the same as them being the same as each other.

Question 9(d)(ii)

(ii) The pressure of the equilibrium mixture is increased.

The temperature is kept at 200 °C.

ICl(g) is a dark brown gas. ICl_3(g) is a yellow gas.

Predict and explain what will happen to the colour of the equilibrium mixture.

prediction *The colour becomes more yellow as more ICl_3 is formed (which is yellow) and less ICl (which is brown)* ✓

explanation *because there are fewer moles of gas on the right-hand side of the equilibrium, increasing the pressure moves the equilibrium position to the side with fewer gas molecules i.e., the right* ✓

[2]

Mark awarded = 2 out of 2

Examiner comment

The candidate must recall their knowledge of the change in position of equilibrium when the pressure is changed and apply their knowledge to the situation. They should understand that increasing the pressure will move the equilibrium to the right because there are fewer moles on the right (equation shows that 2 moles of gas produces 1 mole of gas). The movement to the right leads to more ICl_3 being produced, which is yellow, so they would observe that the colour will become more yellow.

Common mistakes

Candidates often do not mention the colour at all, just mentioning either more ICl_3 or less ICl; the question specifically asks what will happen to the colour so by not mentioning the colour the candidate has not answered the question.

Total mark awarded = 8 out of 8

Question 10

Question 10(a)

10 Air contains a mixture of gases including the noble gases neon, argon, krypton and xenon. These noble gases are monatomic elements.

(a) State what is meant by monatomic.

Consists of single atoms which are not bonded. ✓

..... [1]

Mark awarded = 1 out of 1

Examiner comment

This question requires recall.

Common mistakes

Some candidates will just say that monatomic means 'made of atoms' without reference to the fact that they exist as atoms rather than molecules, i.e. the atoms are not bonded.

Question 10(b)

(b) State why noble gases are unreactive.

Atoms have a filled outer shell of electrons which is stable, and so have no need to gain, lose or share electrons. ✓ [1]

Mark awarded = 1 out of 1

Examiner comment

The candidate is correct and has provided a very complete answer. In order to be awarded the mark however, it would have been sufficient to state either that the atoms do not need to gain or lose electrons, or to state that they have a stable electronic arrangement; the candidate did not need to state both to be awarded full marks.

Question 10(c)

(c) State why fractional distillation can be used to separate a liquid mixture of neon, argon, krypton and xenon.

Each gas has a different boiling point. ✓

..... [1]

Mark awarded = 1 out of 1

Examiner comment

The candidate must recall how the process of fractional distillation separates a liquid mixture.

Common mistakes

Candidates will often confuse how fractional distillation works with other methods of separation and purification and so state melting point or size of molecules.

Question 10(d)

(d) State which noble gas, neon, argon, krypton or xenon, has the fastest rate of diffusion at 20 °C.

Neon ✓

Explain your answer.

Smallest relative atomic mass, so atoms are moving more quickly so therefore diffuse more quickly ✓

[2]

Mark awarded = 2 out of 2

Examiner comment

Candidates must explain the effect of relative molecular mass on the rate of diffusion of gasses (the smallest relative molecular mass diffuses faster) and apply it to the noble gases, using the Periodic Table to find which has the smallest relative atomic mass.

Question 10(e)(i)

(e) Air also contains oxides of nitrogen that are pollutants.

(i) State **one** adverse effect of oxides of nitrogen in the air.

photochemical smog ✓ [1]

Mark awarded = 1 out of 1

Examiner comment

The candidate must recall the adverse effects of oxides of nitrogen in the air. Other correct answers include acid rain and respiratory problems.

Common mistakes

Candidates often confuse the adverse effects of the different air pollutants and so will incorrectly state:

- ozone depletion
- greenhouse gases
- climate change, etc.

Question 10(e)(ii)

(ii) With the aid of a symbol or word equation, explain how oxides of nitrogen such as NO are formed within a car engine.

Nitrogen reacts with oxygen at high temperatures ✓

$N_2 + O_2 \rightarrow 2NO$ ✓

[2]

Mark awarded = 2 out of 2

Examiner comment

Candidates must recall how oxides of nitrogen form in car engines and use this to help them deduce a suitable symbol equation.

Common mistakes

Candidates will often miss out a mark because they do not include the equation.

Some candidates will write an equation using atomic rather than molecular nitrogen and oxygen in air, e.g. N + O → NO

Total mark awarded = 8 out of 8

Question 11

Question 11(a)(i)

11 Table 11.1 shows some information about the homologous series of unbranched carboxylic acids.

Table 11.1

name	structure	boiling point / °C
methanoic acid	HCOOH	101
ethanoic acid	CH_3COOH	118
propanoic acid	CH_3CH_2COOH	141
butanoic acid	$CH_3CH_2CH_2COOH$	164
pentanoic acid	$CH_3CH_2CH_2CH_2COOH$	186

(a) One of the characteristics of a homologous series is that it has a general formula.

(i) Deduce the general formula for the homologous series of unbranched carboxylic acids.

$C_nH_{2n+1}COOH$ ✓ [1]

Mark awarded = 1 out of 1

Examiner comment

Candidates should expect the general formula to be based on C_n, then look for a ratio of C to H, and then include the functional group COOH. Some candidates might recall the general formulae of carboxylic acids from memory.

Question 11(a)(ii)

(ii) Describe two **other** characteristics of a homologous series.

1 same functional group ✓

2 trend in physical properties ✓

[2]

Mark awarded = 2 out of 2

Examiner comment

The candidate uses recall of the general characteristics of a homologous series.

Common mistakes

Some commons misconceptions about general characteristics of a homologous series include:

- trend in chemical properties
- same physical properties
- same formula / same chemical formula.

Question 11(b)

(b) An aqueous solution of propanoic acid is a weak acid.

Define the term acid.

Substance which releases H^+ ions in solution ✓

..... [1]

Mark awarded = 2 out of 2

Examiner comment

The candidate has used recall; an acid is a proton donor.

Common mistakes

Some candidates will give a characteristic of an acid, such as reacts with metals to give hydrogen, rather than giving the definition of an acid.

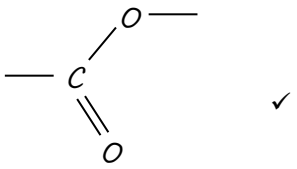
Question 11(c)

(c) Butanoic acid reacts with ethanol to make an ester.

State the name of the ester made and draw the displayed formula of the ester linkage.

name *ethyl butanoate ✓*

displayed formula



✓

[2]

Mark awarded = 2 out of 2

Examiner comment

The candidate is correct.

Common mistakes

Some candidates give the reverse ester, i.e. butyl ethanoate.

Question 11(d)

(d) Ethanoic acid is a liquid at room temperature.

Describe the changes in the arrangement and movement of the molecules of ethanoic acid when it is heated from room temperature to 120 °C.

As heated molecules gain kinetic energy they move more quickly, ✓ the movement is thus more random and the molecules further apart. ✓ Since it boils at 118 °C, the molecules escape the liquid as they boil and so are far apart and moving very quickly and randomly ✓

[3]

Mark awarded = 3 out of 3

Examiner comment

The candidates recalls the boiling point of ethanoic acid, understanding that it will change from a liquid to a gas during the temperature change given. The candidate recalls what they know about the structure of solids, liquids and gases in terms of particle separation, arrangement and motion.

Common mistakes

Candidates will often forget to mention that the molecules are arranged more randomly/irregularly as the temperature increases, costing them a mark.

Total mark awarded = 9 out of 9

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