Bukit View Secondary School

Secondary 4 Express

Preliminary Examination 2024

CANDIDATE NAME

CLASS

INDEX NUMBER

Chemistry **6092/02**

Paper 2

22 Aug 2024

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your candidate name, class and number in the spaces at the top of this page.
Write in dark blue or black pen.
You may use a HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Do not open this booklet until you are told to do so.

Section A
Answer all questions in the spaces provided.
Write your answers in the spaces provided.

Section B
Answer **one** question.
Write your answers in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 22.

The use of an approved scientific calculator is expected, where appropriate.

You may lose marks if you do not show your working or if you do not use appropriate units.

For Examiner's Use	
Section A	
Section B	
Total	/ 80

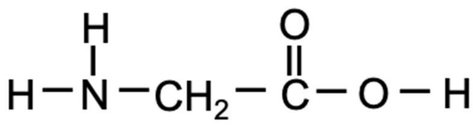
Setter: Mdm Fatimah **Parent's Signature:**__________________

This question paper consists of **22** printed pages , including this cover page.

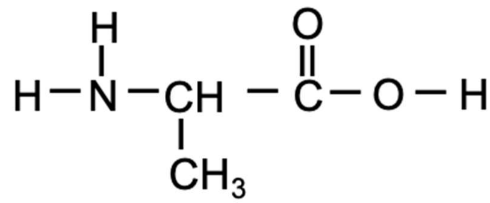
Section A

Answer all questions in this section in the spaces provided.

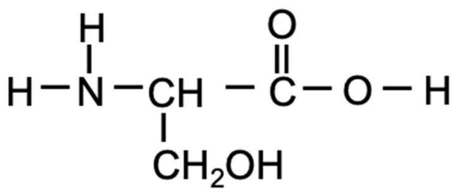
A1 The diagrams show the structures of some amino acids (glycine, alanine and serine) and a polymer (polypropylene).



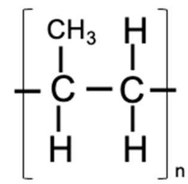
glycine



alanine



serine



polypropylene

(a) Which two compounds undergo condensation?

……[1]

(b) PropEx has the structure of polypropylene.

The molecular mass of PropEx is 8400.

Calculate the number of carbon atoms in each molecule of PropEx.

number of carbon atoms =…………………………………..[1]

(c) One possible structure of a protein is

glycine – alanine – serine

Give the structural formula of the repeating unit of the above protein.

[2]

(d) Individual amino acids can be identified by chromatography. The R_f value of the amino acid glycine is 0.5.

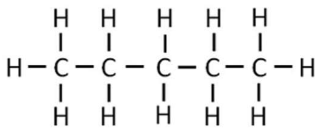
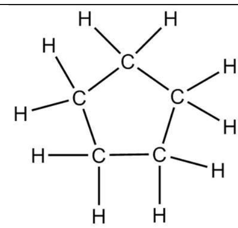
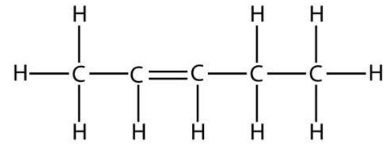
Describe how you could show that glycine was present on a chromatogram.

………..……………………………………………………………………………………………..

…………………………………………………………………………………………………….[1]

[Total: 5]

A2 The diagrams show the structures of some hydrocarbons.

1	2	3
		

(a) Name compound 3.

………[1]

(b) Explain why compounds 2 and 3 are isomers. Include references to molecular formula.

………

………[1]

(c) Draw one other isomer of compound 1.

[2]

(d) A compound commonly found in nail polish removers contains, by mass, 62.1% carbon, 10.3% hydrogen and 27.6% oxygen.

Deduce the empirical formula for this compound.
Show your working.

empirical formula = ………………………[2]

[Total: 6]

[Turn over

A3 Two electrolysis experiments are carried out using inert electrodes.

In experiment 1, molten sodium chloride is electroysed.
In experiment 2, dilute copper(II) chloride is electrolysed.

The results of the experiment are shown in Table 3.1.

Table 3.1

	positive electrode	negative electrode
experiment 1	bubbles formed	grey solid formed
experiment 2	bubbles formed	reddish-brown solid formed

(a) Write ionic half-equations, with state symbols, to show the reactions that happen at the positive and negative electrode for each experiment.

experiment 1:

positive electrode ……………………………………………………………………………….

negative electrode ………………………………………………………………………………

experiment 2:

positive electrode ………………………………………………………………………………

negative electrode ………………………………………………………………………………[4]

(b) A few minutes later, the solution from experiment 2 is tested with Universal Indicator.
The indicator turns red. Identify the compound that turns the Universal Indicator red and explain how it was formed.

compound…………………………………………………………………………………………..

explanation…………………………………………………………………………………………

…………………………………………………………………………………………………...[2]

(c) Experiment 3 was conducted in which copper electrodes were immersed in concentrated copper(II) sulfate solution.

Describe what the student would observe different from experiment 2.

Explain why.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………….[2]

[Total: 8]

A4 Fig. 4.1 shows a laboratory set-up to demonstrate the Haber process for the manufacture of ammonia.

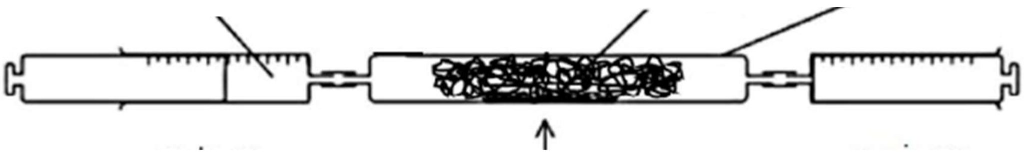


Fig. 4.1

The mixture of nitrogen and hydrogen gases is passed back and forth over the heated iron wool.

The overall reaction can be represented by the equation:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

(a) Suggest two reasons why the mixture of gases are fed back into the reactor continuously.

………

……………………………………………………………………………………………………[2]

(b) Suggest why is it important to ensure that no air is present in the apparatus.

……………………………………………………………………………………………………[1]

(c) Fig. 4.2 shows the yield of ammonia made under different conditions.

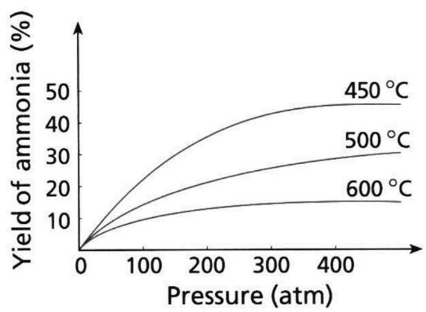


Fig. 4.2

Use the graph to describe how pressure affects the yield of ammonia produced.
Explain your answer in terms of collisions between (reacting) particles.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[3]

[Total: 6]

A5 Glucose, $C_6H_{12}O_6$, is produced during photosynthesis in green plants. Ethanol can be made from glucose. The processes involved can be summarised as follows.

Process 1: Photosynthesis in green plants

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

Process 2: Fermentation of glucose to form ethanol

Process 3: Complete combustion of ethanol

$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

(a) Write a balanced equation for process 2.

……………………………………………………………………………………………………….[1]

(b) State **all** the essential conditions for the fermentation of aqueous glucose in process 2.

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….[1]

(c) Ethanol can also be made from ethene.

Explain why ethanol made from ethene is a non-renewable fuel but that made from glucose is a renewable fuel.

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….[2]

(d) An organic product is produced when ethanol and warm, acidified potassium manganate(VII) are reacted.

(i) Name the organic product.

……………………………………………………………………………………………….[1]

(ii) Draw the product formed when the organic product in **(d)(i)** reacts with propanol.

[1]

[Total: 6]

A6 In the laboratory, chlorine dioxide is produced from the reaction between aqueous sodium chlorate ($NaClO_3$), solid oxalic acid $(COOH)_2$ and sulfuric acid. The other products are aqueous sodium sulfate, carbon dioxide and water.

(a) Write a balanced chemical equation for the reaction.

....[1]

(b) 5.00 g of impure sample of hydrated oxalic acid, $(COOH)_2.2H_2O$, was dissolved in 1.00 dm^3 of water. 25.0 cm^3 of this solution was neutralised by 14.0 cm^3 of 0.100 mol/dm^3 sodium hydroxide using a suitable indicator. The equation for the reaction is shown.

$$(COOH)_2(aq) + 2NaOH(aq) \rightarrow (COONa)_2(aq) + 2H_2O(l)$$

Calculate the percentage purity of the hydrated oxalic acid sample.

percentage purity = ...[3]

(c) A neutral solution of the sodium salt, which still contains the indicator, is left.

Describe how you could obtain a neutral solution of the sodium salt, which does not contain an indicator.

....

....

....[2]

[Total: 6]

A7 The rate of reaction of iron with aqueous bromine is determined using the apparatus shown below in Fig. 7.1. The equation for the reaction is given below.

$$Fe\,(s) + Br_2\,(aq) \rightarrow FeBr_2\,(aq) \qquad \Delta H = -250\text{ kJ/mol}$$

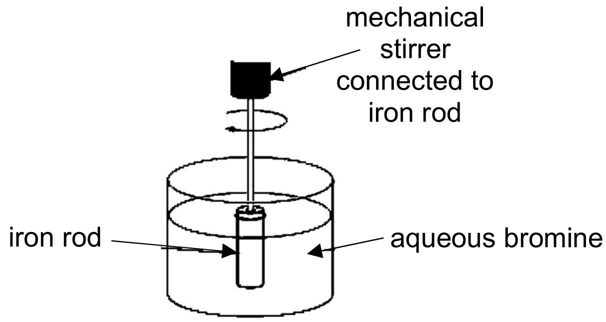


Fig. 7.1

The mass of the iron is measured at regular intervals.
The results are shown in Table 7.1 below.

Table 7.1

time / s	mass of iron / mg
0	63.8
10	60.2
20	55.7
30	46.5
40	33.1

(a) Describe and explain the trend observed from Table 7.1.

………………………………………………………………………………………………………

………………………………………………………………………………………………………

…………………………………………………………………………………………………….[2]

(b) Using ideas about collisions between particles, explain the purpose of the mechanical stirrer.

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

…………………………………………………………………………………………………….[2]

(c) Calculate the enthalpy change when 8.4 g of iron is reacted with 4 dm^3 of 0.05 mol/dm^3 of aqueous bromine.

enthalpy change = …………………………..[3]

[Total: 7]

A8 Table 8.1 shows information about the atomic radii and ionic radii of some Group 1 and Group 17 elements.

Table 8.1

element	atomic radius/pm	ionic radius/pm
lithium	152	68
sodium	185	98
chlorine	99	181
bromine	115	196

(a) Describe, in terms of electron loss and gain, how and why a lithium atom reacts with a chlorine atom.

....

....

....

....[2]

(b) Describe and explain, in terms of electron shells, the change in radius when a lithium atom forms a lithium ion.

....

....

....

....[2]

(c) What would you observe when aqueous bromine is added to lithium chloride solution?

Explain your reasoning.

....

....

....

....[2]

[Total: 6]

A9 **(a)** Nitric acid can be made from nitrogen(II) oxide as shown by the equation.

Stage 1: Ammonia is converted to nitrogen(II) oxide.

$4NH_3\ (g) + 5O_2\ (g) \rightarrow 4NO\ (g) + 6H_2O\ (g)\ \Delta H = -950\ kJ/mol$

Stage 2: Nitrogen(II) oxide is converted to nitric acid.

$4NO\ (g) + 2H_2O\ (g) + 3O_2\ (g) \rightarrow 4HNO_3\ (aq)\ \Delta H = -126\ kJ/mol$

Suggest reasons why the enthalpy change is more negative for stage 1 than stage 2. In your answer, include the bonds broken and bonds formed during each reaction.

………

………

………

………[1]

(b) Concentrated aqueous nitric acid releases fumes of nitric acid gas.

A long glass tube is set up as shown in Fig. 9.1.

Fig. 9.1

Use the kinetic particle model to explain why the blue litmus paper turns red after a short while.

………

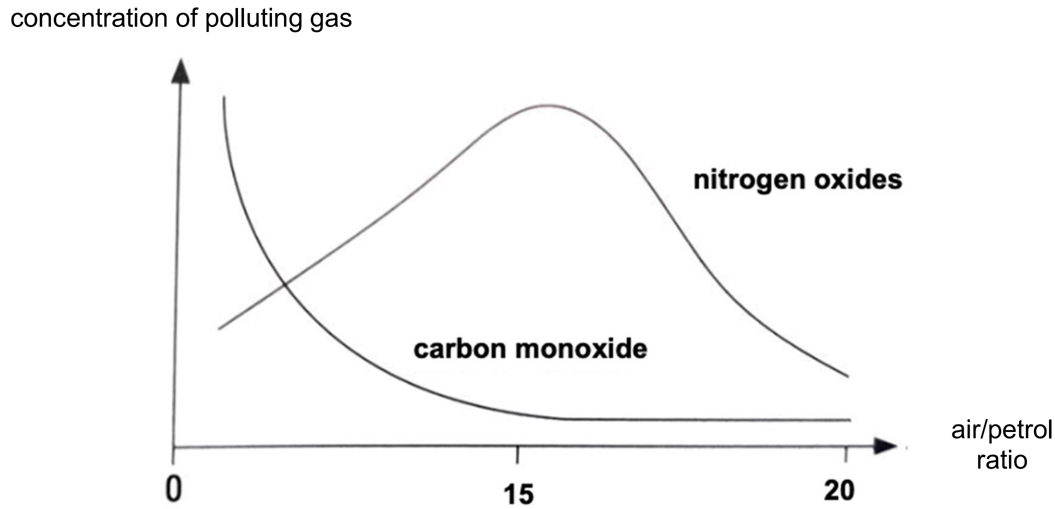
………

………

………[2]

(c) The amount of air mixed with petrol vapour in an engine can be varied. Two common pollutants in the exhaust gases from a motorcar are carbon monoxide and nitrogen oxides.

The graph shows how the amounts of these pollutants in the exhaust gases depend on the composition of the air/petrol mixture.



(i) Describe and explain how the concentration of carbon monoxide changes with the composition of the air/petrol mixture.

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

(ii) Nitrogen monoxide can be removed from vehicle exhaust emissions by catalytic convertors when it is reduced by carbon monoxide.

Write a chemical equation to show how this takes place.

……………………………………………………………………………………………………[1]

(d) One major pollutant of these reactions is nitrogen monoxide, NO. Nitrogen monoxide plays a significant role in the depletion of the ozone layer in the stratosphere (upper region of the atmosphere). The chemical formula of ozone is O_3.

equation 1 $NO + O_3 \rightarrow NO_2 + O_2$
equation 2 $NO_2 + \text{sunlight} \rightarrow NO + O$ (initiation)
$NO + O_3 \rightarrow NO_2 + O_2$ (propagation)

One molecule of nitrogen monoxide can destroy thousands of ozone molecules.

Use equations 1 and 2 to explain why.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

[Total: 8]

A10 Fenton’s reagent is a term that is used to denote a solution of hydrogen peroxide that contains the ferrous ion (in which iron exhibits an oxidation state of +2). The ferrous ion works as a catalyst and promotes the oxidation of contaminants in wastewater. It can be noted that Fenton’s reagent is typically prepared by dissolving iron(II) sulfate ($FeSO_4$) in hydrogen peroxide in an acidic medium.

Fenton's reagent is effective in oxidizing and breaking down a wide range of organic pollutants in water and soil remediation. The hydroxyl radical (OH•) produced by Fenton's reaction is a powerful disinfectant that can inactivate bacteria, viruses, and other pathogens in water. A hydroxyl radical, denoted by •OH, is a highly reactive molecule consisting of a single hydrogen atom bonded to an oxygen atom that has lost one electron.

Oxidation of an organic compound by Fenton's reagent is rapid and exothermic, resulting in the oxidation of contaminants to primarily carbon dioxide and water. The effectiveness of Fenton's reagent depends on factors like pH, iron concentration, and the type of organic pollutants present.

Similar to water purification, Fenton's reagent can degrade various organic pollutants in soil, including:

- Petroleum hydrocarbons (like gasoline or oil spills)
- Polycyclic aromatic hydrocarbons (PAHs) - a common environmental contaminant

Table 10.1 shows the enthalpy of combustion values of common petroleum hydrocarbons:

Table 10.1

hydrocarbon	enthalpy of combustion (ΔH)/ kJ/mol
hexane	–4184.0
heptane	–4837.2
octane	–5490.4

The overall reaction in Fenton's reagent for water purification can be represented by a series of steps:

Initiation: The initiation step is slow and is where the key oxidizing agent, the hydroxyl radical (•OH), is formed. Iron (Fe^{2+}) reacts with hydrogen peroxide (H_2O_2) to generate •OH, hydroxide (OH^-), and ferric iron (Fe^{3+}). The hydroxyl radical is highly reactive and non-selective, attacking organic pollutants (R) present in the water. This breaks down the pollutants into smaller molecules (oxidation products).

Fe^{2+} (aq) + H_2O_2 (aq) → Fe^{3+} (aq) + OH^- (aq) + •OH (aq) (slow)

- Fe^{2+} (aq): Ferrous iron (catalyst)
- H_2O_2 (aq): Hydrogen peroxide
- Fe^{3+} (aq): Ferric iron
- OH^- (aq): Hydroxide ion
- •OH (aq): Hydroxyl radical (the primary oxidizing agent)

Propagation: The propagation step involves a series of faster reactions. Here, •OH can further react with H_2O_2 or directly target organic pollutants. Additionally, Fe^{3+} can react with H_2O_2 to form an intermediate (Fe-OOH^{2+}) that can eventually decompose back to Fe^{2+}, releasing another •OH in the process (alternative pathway).

Fe^{3+} + H_2O_2 → HO_2• + Fe^{2+} + H^+

- HO_2• (aq): Hydroperoxyl radical

Termination: Termination steps involve the consumption of hydroxyl radicals through their interaction with each other or with HO_2• radicals, ultimately forming water and oxygen.

•OH (aq) + •OH (aq) → H_2O_2 (aq) (fast)
•OH (aq) + HO_2• (aq) → H_2O + O_2 (aq) (fast)

Advantages of Fenton's Reagent:

- Broad-spectrum treatment: Effective against a wide range of organic pollutants.
- Relatively simple and inexpensive: Uses readily available chemicals (hydrogen peroxide and iron salts).
- In situ treatment: Can be applied directly to contaminated soil or water.

Limitations of Fenton's Reagent:

- Non-selective: Can also attack desirable organic matter in water or soil.
- pH dependent: Optimal performance at acidic pH, which may require adjustments in some cases.
- Potential for iron precipitation: Iron from the reaction can form precipitates that may require further treatment.

Source: https://byjus.com/chemistry/fentons-reaction/

(a) Using oxidation states, show that the initiation step is a redox reaction.

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….[2]

(b) The common isotopes of the element oxygen are ^{16}O, ^{17}O and ^{18}O.
The common isotopes of the element hydrogen are ^{1}H, ^{2}H and ^{3}H.

Determine the highest value of the relative molecular mass of a hydroxyl radical molecule.

relative molecular mass ………………………….[1]

(c) Explain, using a ‘dot and cross’ diagram of the bonding in one hydroxyl radical molecule, why a hydroxyl radical is very reactive. Use only outer shells electrons in your drawing.

………

………

………[2]

(d) Under acidic medium, Fenton’s reaction proceeds at a very rapid rate compared to alkaline conditions. Explain why alkaline conditions are not preferred.

………

………

………[2]

(e) Complete the energy profile diagram for the oxidation of octane molecule by Fenton's reagent.

Your diagram should show and label:

- the reactants and products of the reaction,
- the activation energy, E_a for the catalysed and uncatalysed reactions,
- the enthalpy change of the reaction.

[3]

(f) The hydroxyl radical can break down organic molecules into smaller substances.

Explain how this can be both beneficial and harmful when Fenton's reagent is added to an oil spill in the ocean.

beneficial……………………………………………………………………………………….

………………………………………………………………………………………………….

harmful………………………………………………………………………………………

…………………………………………………………………………………………......[2]

[Total: 12]

Section B

Answer **one** question from this section.

B11 In an experiment, hydrogen gas was passed over equal masses of three heated metal oxides in identical porcelain boats as shown in Fig. 11.1.

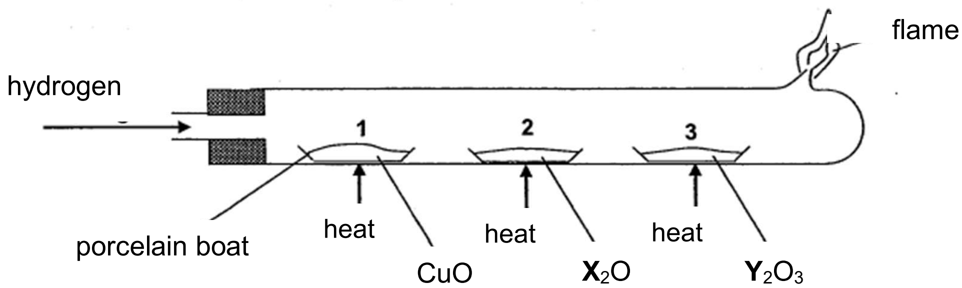


Fig. 11.1

The porcelain boats were weighed 5 minutes into the experiment. After weighing, the experiment was allowed to continue for another 30 minutes where no further changes were observed. At the end of the experiment, the heat source was turned off. However, the hydrogen gas is kept flowing until the tube has cooled down.

Table 11.1 shows some data from this experiment.

Table 11.1

	at the start of experiment	5 minutes into the experiment	at the end of experiment
mass of empty porcelain boat/ g	16.35	-	16.35
mass of porcelain boat **1** and its content/ g	22.35	21.15	20.15
mass of porcelain boat **2** and its content/ g	22.35	22.35	22.35
mass of porcelain boat **3** and its content/ g	22.35	21.20	20.55

(a) Put the three metals, Cu, **X**, and **Y**, in the order of their reactivity, starting with the most reactive.

Explain your answer using the results obtained from Table 11.1. Include a balanced chemical equation to support your answer.

…………………………………………………………………………………………………….….

…………………………………………………………………………………………………….….

…………………………………………………………………………………………………….….

…………………………………………………………………………………………………….….

…………………………………………………………………………………………………….….

……………………………………………………………………………………………………...

………………………………………………………………………………………………...….[4]

(b) **(i)** Use the data given in Table 11.1 to calculate the mass of oxygen and the mass of **Y** in $\mathbf{Y}_2O_3$ in porcelain boat **3**.

mass of oxygen in $\mathbf{Y}_2O_3$ = ……………………….g

mass of **Y** in $\mathbf{Y}_2O_3$ = ……………………….g [2]

(ii) Using your answers in **(b)(i)**, calculate the relative atomic mass of **Y** and identify **Y**.

relative atomic mass of **Y** = ……………………….

identity of **Y** =……………………….[2]

(c) $\mathbf{X}_2O$ has a relatively high melting point.

With reference to the structure and bonding of $\mathbf{X}_2O$, explain why $\mathbf{X}_2O$ has a high melting point.

………………………………………………………………………………………………………

………………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

[Total: 10]

[Turn over

B12 Silicon is extracted from silicon dioxide in sand by heating the sand to 2000°C in a furnace with carbon. Carbon monoxide is one of the products.

Sand also contains small amounts of aluminium oxide. Aluminium oxide remains in the silicon after the reaction with carbon.

(a) Write a balanced chemical equation for the reaction between silicon dioxide and carbon.

....[1]

(b) Suggest the order of reactivity of carbon, silicon and aluminium from the least to most reactive. Explain your answer using ideas about reduction.

....

....

....[2]

(c) Table 12.1 shows information about oxides of carbon, silicon and aluminium.

Table 12.1

oxide	melting point/ °C	boiling point/ °C	electrical conductivity
carbon monoxide	–205	–192	does not conduct
silicon dioxide	1600	2230	does not conduct
aluminium oxide	2000	2980	only conducts when molten

Use ideas about bonding and structure to explain the differences between the properties of the oxides of carbon, silicon and aluminium.

....

....

....

....

....

....

....

....[4]

(d) In a sample of aluminium–silicon alloy, 2.8 mol of aluminium is present. Based on Table 12.2, find the mass of the impurities in the sample.

Table 12.2

element	percentage by mass (%)
aluminium	95.85
silicon	0.40

mass of impurities = ……………………………g [3]

[Total: 10]

The Periodic Table of Elements

Key

proton (atomic) number atomic symbol name relative atomic mass

Group

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

The Avogadro constant, L = 6.02 x 10^{23} mol^{-1}