Questions are for both separate science and combined science students unless indicated in the question

Q1.

This question is about acids and their reactions.

Acids can be either weak or strong.

(a) What is meant by 'a **weak** acid'? **(HT only)**

An acid which is partially ionised in aqueous solution.

(2)

(b) Explain what happens to the pH of an acid as the acid is diluted with water.

pH increases (becomes less acidic) because the concentration of hydrogen ions, H^+ decreases

(2)

(c) A student does a titration to find the volume of acid needed to neutralise an alkali.

The student fills a burette with the acid.

Give **three** more steps the student must do before adding the acid to the alkali from the burette. **(chemistry only)**

You should name any equipment used.

1 Use a volumetric pipette to add the alkali into a conical flask.

2 Add an indicator (use a white tile)

3 Record the initial burette reading.

(3)

(d) The student titrated a solution containing 0.0045 moles of sodium hydroxide with 0.15 mol/dm^3 hydrochloric acid.

The equation for the reaction is:

$$NaOH + HCl \rightarrow NaCl + H_2O$$
$$1 : 1$$

Calculate the volume of hydrochloric acid in cm^3 needed in the titration. **(chemistry only) (HT only)**

N° moles HCl needed, n(HCl) = 0·0045 moles

Volume HCl = $\frac{\text{N° moles}}{\text{concentration}} = \frac{0{\cdot}0045 \text{ mol}}{0{\cdot}15 \text{ mol dm}^{-3}} = 0{\cdot}03$ dm^3

1 dm^3 = 1000 cm^3

0·03 dm^3 = 30 cm^3

Volume of acid = 30 cm^3

(2)

(e) A calcium atom is larger than a magnesium atom.

Explain why calcium reacts more vigorously than magnesium with hydrochloric acid of the same concentration.

Calcium's outer shell electrons are further from the nucleus, so the outer electrons are less strongly attracted to the nucleus. These are lost more easily to form a positive ion.

(3)

(Total 12 marks)

Q2.

This question is about elements in the periodic table.

(a) Argon has the atomic number 18

Explain why argon does **not** form compounds.

Answer in terms of electrons.

Atoms of Argon have a stable arrangement of electrons. So argon atoms do not share or transfer electrons.

(2)

(b) Phosphorus (P) is the element below nitrogen in the periodic table.

Predict the formula of the compound formed between phosphorus and hydrogen.

Formula = PH_3

5

Gr 5 ∴ needs 8-5 = 3e⁻

(1)

Each H 'shares' NH_3 ammon

(c) Tellurium is the element with atomic number 52

Predict whether tellurium reacts with metals.

Explain your answer.

Answer in terms of the position of tellurium in the periodic table.

Yes, tellerium will react with metals as it sits towards the right of the periodic table (Group 6 - same as O and S). So, tellerium is a non-metal, it will gain electrons from a metal.

6

(2)

14 N nitrogen 7

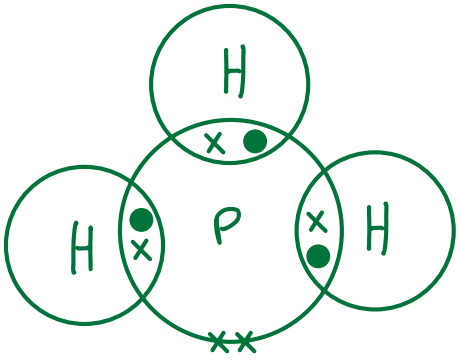
31 P phosphorus 15

16 O oxygen 8

32 S sulfur 16

79 Se selenium 34

128 Te tellurium 52



2

9 **Be** beryllium 4
24 **Mg** magnesium 12
40 **Ca** calcium 20
88 **Sr** strontium 38
137 **Ba** barium 56
[226]

Barium (Ba) is an element in Group 2 of the periodic table.

Barium reacts with hydrochloric acid.

(d) Suggest **two** observations that could be made when barium reacts with hydrochloric acid.

1 Effervescence / fizzing

2 Barium disappears to form a colourless solution.

(Temp. increases)

(2)

(e) Write a balanced symbol equation for the reaction between barium and hydrochloric acid.

$Ba + 2HCl \rightarrow BaCl_2 + H_2$

(3)

(Total 10 marks)

Ba, Group 2, ∴ ⇒ Ba^{2+} H^+Cl^- H^+Cl^-

Ba^{2+} Cl^- Cl^- } $BaCl_2$

H^+ H^+ } H_2

Q3.

This question is about displacement reactions.

Iron is extracted from iron oxide by a displacement reaction with carbon.

The equation for the reaction is:

$$Fe_2O_3 + 3\,C \rightarrow 2\,Fe + 3\,CO$$

(a) Which substance in the equation is reduced?

Give **one** reason for your answer.

Answer in terms of oxygen.

Substance reduced Fe_2O_3

Reason Fe_2O_3 loses oxygen

(2)

(b) Which expression shows how to calculate the mass of carbon needed to produce 1 mole of iron from iron oxide? **(HT only)**

Relative atomic mass (A_r): C = 12

Tick (✓) **one** box.

$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$

3 : 2

N° moles needed = $\times 3 \div 2$

$= \frac{3}{2} \times A_r(C)$

- $\frac{1}{3} \times 12$ g ☐
- $\frac{3}{2} \times 12$ g ☑
- 1×12 g ☐
- 3×12 g ☐

(1)

A student investigated displacement reactions of four different metals represented by **A**, **B**, **C** and **D**.

A, **B**, **C** and **D** are **not** the actual chemical symbols for the metals.

The student:

- added each metal to aqueous solutions of the metal nitrates
- observed whether a reaction took place.

The table below shows information about three of the reaction mixtures.

Reaction	Metal	Metal nitrate solution	Equation
1	**A**	**B**NO_3	**A** + 2**B**NO_3 → 2**B** + **A**$(NO_3)_2$
2	**C**	**A**$(NO_3)_2$	2**C** + 3**A**$(NO_3)_2$ → 3**A** + 2**C**$(NO_3)_3$
3	**C**	**D**$(NO_3)_2$	no reaction

(c) The ionic equation for **Reaction 1** is:

$$\mathbf{A} + 2\,\mathbf{B}^{+} \rightarrow 2\,\mathbf{B} + \mathbf{A}^{2+}$$

Why is this a redox reaction? **(HT only)**

Tick (✓) **one** box.

A gains electrons and **B**$^{+}$ loses electrons.	☐
A loses electrons and **B**$^{+}$ gains electrons.	✓
Both **A** and **B**$^{+}$ gain electrons.	☐
Both **A** and **B**$^{+}$ lose electrons.	☐

(1)

(d) Which of the four metals has the greatest tendency to form positive ions?

Use the table above.

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ✓

(1)

(e) The nitrate ion has the formula NO_3^-

Which of the four metals could be aluminium?

Explain your answer.

Use the table above.

Metal C

Explanation Aluminium forms ions with charge 3+, so 3 nitrate ions are needed for 1 aluminium ion.

(3)

(f) Metal **X** is extracted from an oxide of metal **X** by reaction with hydrogen.

The equation for the reaction is:

$$\mathbf{X}O_3 + 3\ H_2 \rightarrow \mathbf{X} + 3\ H_2O$$

The percentage atom economy for obtaining metal **X** by this method is 77.3%.

Calculate the relative atomic mass (*A*r) of metal **X**. **(chemistry only) (HT only)**

Relative atomic masses (A_r): H = 1 O = 16

Percentage atom economy =

$$\frac{A_r(X)}{A_r(X) + 54} \times 100 = 77.3\%$$

$$100\ A_r(X) = 77.3\,(A_r(X) + 54)$$

$$100\ A_r(X) - 77.3A_r(X) = 4174.2$$

$$22.7A_r(X) = 4174.2$$

$$A_r(X) = 183.89$$

Relative atomic mass (A_r) = 184

(4)

(Total 12 marks)

Q4.

This question is about zinc and compounds of zinc.

A student produces pure crystals of zinc chloride by reacting zinc oxide with hydrochloric acid.

The equation for the reaction is:

$$ZnO(s) + 2\ HCl(aq) \rightarrow ZnCl_2(aq) + H_2O(l)$$

(a) The student adds zinc oxide to hydrochloric acid until the zinc oxide is in excess.

Give **one** observation that the student could make to show that the zinc oxide is in excess.

There is some zinc oxide ZnO solid remaining

(1)

(b) Why is excess zinc oxide used rather than excess hydrochloric acid?

Zinc oxide can be filtered off easily

(1)

(c) Name **one other** compound that the student could add to hydrochloric acid to produce zinc chloride.

Zinc hydroxide $Zn(OH)_2$

Zinc carbonate $ZnCO_3$

(1)

(d) Describe how the student should obtain crystals of zinc chloride from a solution of zinc chloride.

Heat the solution until crystallisation point is reached (when crystals start to form).

Leave the solution to cool and crystallise.

(2)

Zinc chloride is also produced in a displacement reaction between zinc and copper chloride solution.

The equation for the reaction is:

$$Zn + CuCl_2 \rightarrow ZnCl_2 + Cu$$

(e) Complete the ionic equation for this reaction. **(HT only)**

$$Zn + \underline{\quad Cu^{2+} \quad} \rightarrow Zn^{2+} + \underline{\quad Cu \quad}$$

(1)

(f) Why is zinc described as being oxidised in this reaction? **(HT only)**

OIL RIG

Zinc is oxidised as it loses 2 electrons.

(1)

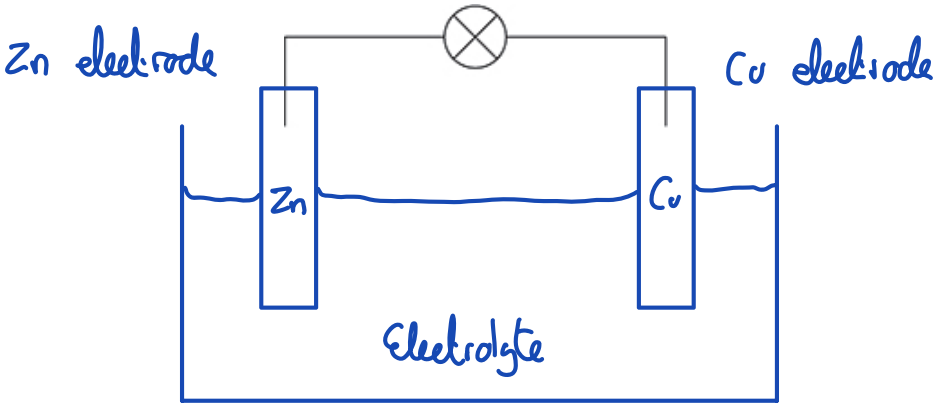
(g) Zinc and copper can be used with another substance to produce electricity.

Complete the figure below to show how zinc, copper and another substance can be used to light a lamp.

Label:

- zinc
- copper
- the other substance used.

The symbol  represents the lamp.



(3)

(Total 10 marks)

Q5.

This question is about groups in the periodic table.

The elements in Group 1 become more reactive going down the group.

Rubidium is below potassium in Group 1.

(a) Rubidium and potassium are added to water.

Predict **one** observation you would see that shows that rubidium is more reactive than potassium.

More vigorous bubbling for Rb
(brighter flame)

(1)

(b) Explain why rubidium is more reactive than potassium.

Rubidium's outer shell electrons are further from the nucleus, so the outer electrons are less strongly attracted to the nucleus. These are lost more easily to form a positive ion.

(3)

(c) Complete the equation for the reaction of rubidium with water.

You should balance the equation.

$$2\,Rb + 2\,H_2O \rightarrow 2\,RbOH + H_2$$

(3)

$2Rb^+$ $\quad$ $H-OH$
$2H^+\ OH^-$

Rb^+OH^- $\quad$ H^+ } H_2
H^+ }

The noble gases are in Group 0.

(d) Which is a correct statement about the noble gases?

Tick (✓) **one** box.

The noble gases all have atoms with eight electrons in the outer shell.	☐
The noble gases have boiling points that increase going down the group.	✓
The noble gases have molecules with two atoms.	☐
The noble gases react with metals to form ionic compounds.	☐

(1)

(e) The table below shows information about the three isotopes of neon.

Mass number	Percentage abundance (%)
20	90.48
21	0.27
22	9.25

Calculate the relative atomic mass (A_r) of neon.

Give your answer to 3 significant figures.

$A_r = \frac{(20 \times 90.48) + (21 \times 0.27) + (22 \times 9.25)}{100}$

$A_r = \frac{1809.6 + 5.67 + 203.5}{100} = 20.1877$

Relative atomic mass (3 significant figures) = 20.2

(3)

(Total 11 marks)

Q6.

This question is about silicon and compounds of silicon.

(a) The reactivity series sometimes includes non-metals such as carbon, hydrogen and silicon.

Silicon can be extracted by reducing silicon dioxide with different substances.

The equation for one possible reaction is:

$$2\ C(s) + SiO_2(s) \rightarrow Si(s) + 2\ CO(g)$$

Explain what this reaction shows about the position of silicon in the reactivity series.

Silicon is less reactive than carbon because carbon displaces silicon from SiO_2

(2)

(b) Aluminium also reduces silicon dioxide.

Carbon is used rather than aluminium to reduce silicon dioxide because carbon is cheaper than aluminium.

Carbon can be obtained by heating coal.

Aluminium is obtained from aluminium oxide.

Explain why aluminium is more expensive than carbon.

More energy is required to obtain aluminium because aluminium is obtained from aluminium oxide by electrolysis.

(2)

Magnesium also reduces silicon dioxide.

The equation for the reaction is:

$$2\ Mg(s) + SiO_2(s) \rightarrow Si(s) + 2\ MgO(s)$$

(c) Give **one** reason why the products are difficult to separate if magnesium is used to reduce silicon dioxide.

Both products are solid.

(1)

2 : 1

$2Mg + SiO_2 \rightarrow Si + 2MgO$

∝ 1.2kg

(d) Calculate the minimum mass in grams of magnesium needed to completely reduce 1.2 kg of silicon dioxide. **(HT only)**

Relative atomic masses (A_r): O = 16 Mg = 24 Si = 28

$M_r(SiO_2) = 28 + (16 \times 2) = 60\ g\ mol^{-1}$

N° moles SiO_2:

Mass of SiO_2 = 1.2kg = 1200g

$n(SiO_2) = \frac{1200\ g}{60\ g\ mol^{-1}} = 20$ moles

Min mass of Mg:

N° moles Mg = 20 × 2 = 40 moles

mass of Mg = 40g × 24g mol^{-1}

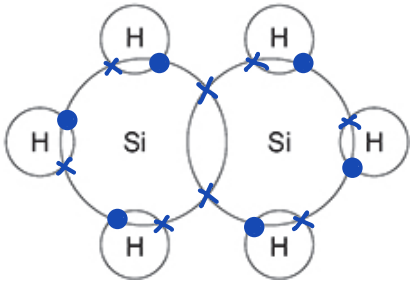
= 960g

Minimum mass of magnesium = 960 g

(5)

Si_2H_6 is a covalent compound of silicon and hydrogen.

(e) Complete the figure below to show the outer shell electrons in a molecule of Si_2H_6



(1)

(f) Si_2H_6 reacts with oxygen.

The equation for the reaction is:

limiting reactant ↓

$$2\ Si_2H_6(g) + 7\ O_2(g) \rightarrow 4\ SiO_2(s) + 6\ H_2O(g)$$

2 : 7 : 6

30 cm^3 of Si_2H_6 is reacted with 150 cm^3 (an excess) of oxygen.

Calculate the total volume of gases present after the reaction. **(chemistry only) (HT only)**

All volumes of gases are measured at the same temperature and pressure.

Volume of Si_2H_6 = 30 cm^3

Vol. of O_2 needed = 30 cm^3 × $\frac{7}{2}$ = 105 cm^3

Excess O_2 remaining = 150 − 105 = 45 cm^3

Volume of $H_2O_{(g)}$ = 30 cm^3 × $\frac{6}{2}$ = 90 cm^3

Total Volume gases remaining = 45 cm^3 (O_2) + 90 cm^3 (H_2O) = 135 cm^3

Volume of gases = 135 cm^3

(4)

(Total 15 marks)