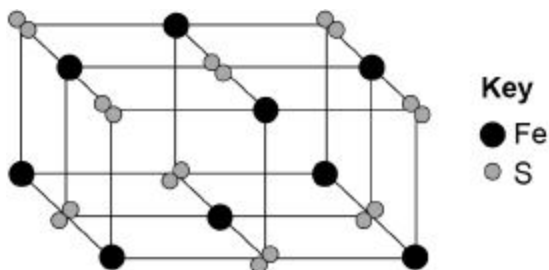**1** This question is about metals and metal compounds.

(a) Iron pyrites is an ionic compound.

The diagram below shows a structure for iron pyrites.

Key
● Fe
○ S

Determine the formula of iron pyrites.

Use the diagram above.

_____

(1)

(b) An atom of iron is represented as $^{56}_{26}Fe$

Give the number of protons, neutrons and electrons in this atom of iron.

Number of protons   _____

Number of neutrons _____

Number of electrons _____

(3)

(c) Iron is a transition metal.

Sodium is a Group 1 metal.

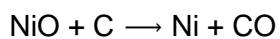Give **two** differences between the properties of iron and sodium.

1. _____

_____

2. _____

_____

(2)

Nickel is extracted from nickel oxide by reduction with carbon.

(d)   Explain why carbon can be used to extract nickel from nickel oxide.

_____

_____

_____

_____

(2)

(e)   An equation for the reaction is:

$$NiO + C \longrightarrow Ni + CO$$

Calculate the percentage atom economy for the reaction to produce nickel.

Relative atomic masses (A_r):   C = 12   Ni = 59

Relative formula mass (M_r):   NiO = 75

Give your answer to 3 significant figures.

_____

_____

_____

_____

_____

_____

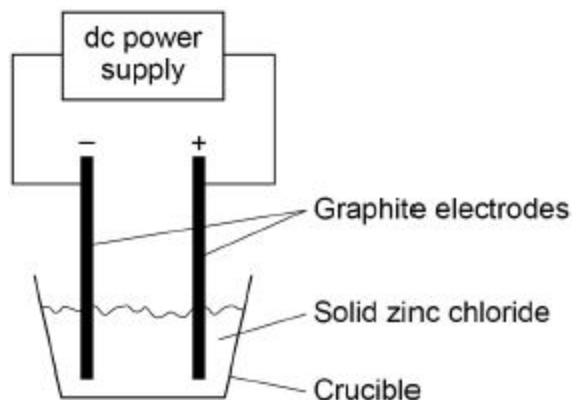Percentage atom economy = _____ %

(3)
(Total 11 marks)

2 A student investigated the electrolysis of different substances.

Figure 1 shows the apparatus.

Figure 1

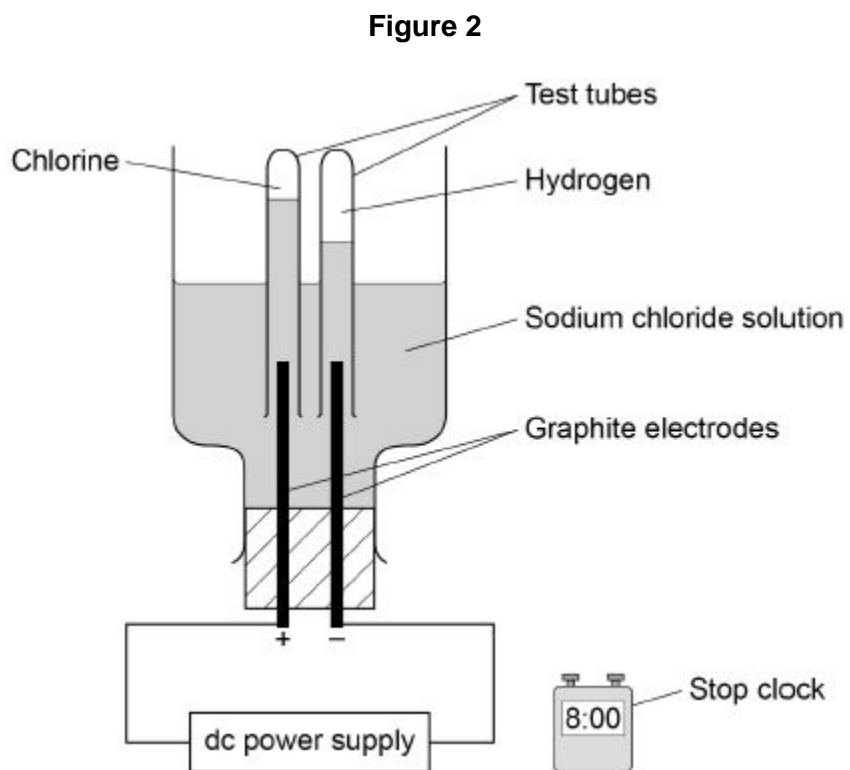(a) Explain why electrolysis would not take place in the apparatus shown in **Figure 1**.

_____

_____

_____

_____

(2)

(b) Explain why graphite conducts electricity.

Answer in terms of the structure and bonding in graphite.

_____

_____

_____

_____

_____

_____

(3)

The student investigated how the volume of gases produced changes with time in the electrolysis of sodium chloride solution.

Figure 2 shows the apparatus.

Figure 2

(c)　The student made an error in selecting the apparatus for this investigation.

How should the apparatus be changed?

Give **one** reason for your answer.
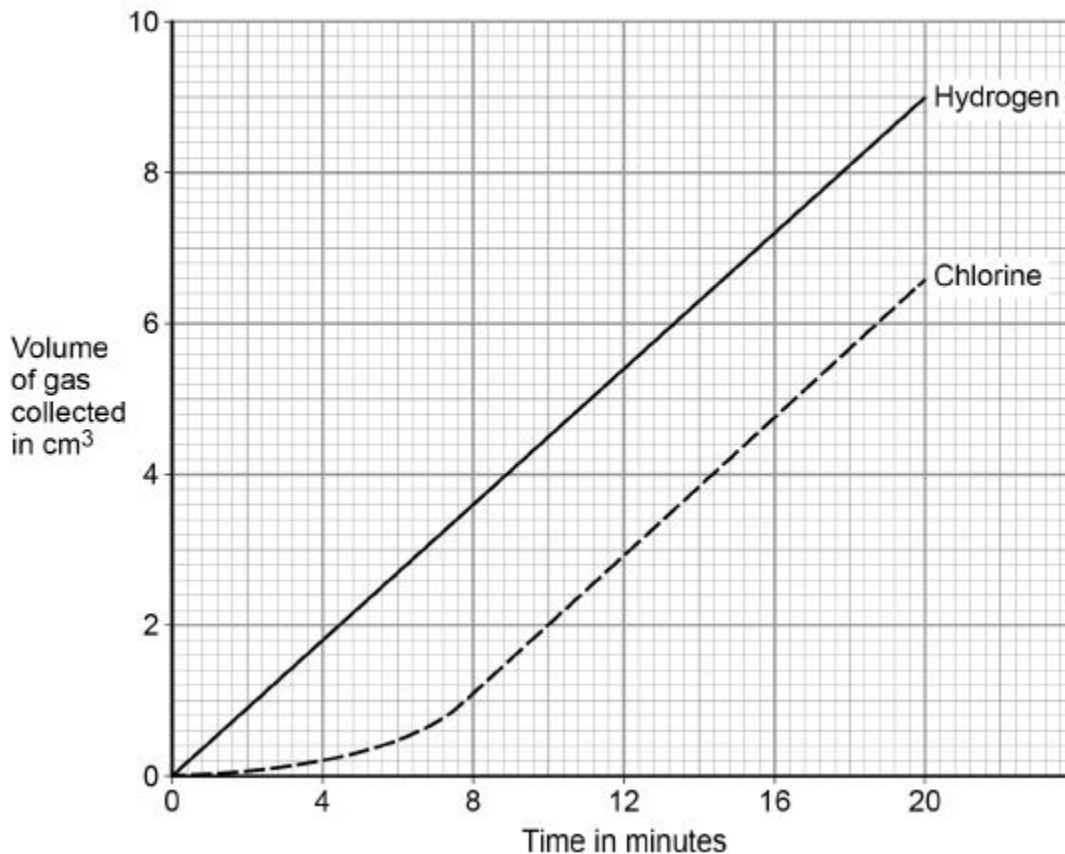
_____

_____

_____

_____

(2)

Another student used the correct apparatus.

This student measured the volumes of gases collected every minute for 20 minutes.

Figure 3 shows the student's results.

Figure 3

(d)   Describe the trends shown in the results.

Use values from **Figure 3**.

_____

_____

_____

_____

_____

_____

(3)

(e)   The number of moles of each gas produced at the electrodes is the same.

No gas escapes from the apparatus.

Suggest **one** reason for the difference in volume of each gas collected.

_____

_____

(1)

(f)   Calculate the amount in moles of chlorine collected after 20 minutes.

Use **Figure 3**.

The volume of one mole of any gas at room temperature and pressure is 24.0 dm^3

Give your answer in standard form.

_____

_____

_____
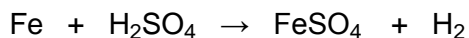
_____

Moles of chlorine = _____ mol

(3)

(Total 14 marks)

3   'Iron tablets' usually contain iron sulphate (FeSO$_4$).

(a)   This salt can be made by reacting iron with sulphuric acid.

$$Fe \ + \ H_2SO_4 \ \rightarrow \ FeSO_4 \ + \ H_2$$

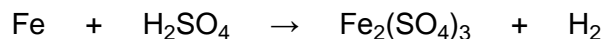Calculate the mass of iron sulphate that could be obtained from 4 g of iron.

(Relative atomic masses: Fe = 56, H = 1, O = 16, S = 32)

_____

_____

_____

_____

_____

_____

Mass of iron sulphate = _____ g

(3)

(b)   Under different conditions, another type of iron sulphate may form.
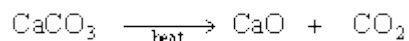   Balance the symbol equation for this reaction.

$$Fe \quad + \quad H_2SO_4 \quad \rightarrow \quad Fe_2(SO_4)_3 \quad + \quad H_2$$

(1)
(Total 4 marks)

4   Limestone ($CaCO_3$) is a raw material. On strong heating it is converted to calcium oxide which is a very useful substance.

$$CaCO_3 \xrightarrow[heat]{} CaO \quad + \quad CO_2$$

(a)   Calculate the formula mass (M_r) of calcium carbonate.

_____

 M_r of calcium carbonate = _____

(2)

(b)   About 60 million tonnes of calcium oxide is made in Britain each year.
       Calculate the mass of calcium carbonate needed to make this amount of calcium oxide.

_____

_____

_____

_____

_____

_____

              Mass of calcium carbonate needed = _____ million tonnes

(4)

(c)   Water is added to some of the calcium oxide produced in a process known as 'slaking'. The product of this reaction is used to make plaster.

       $CaO_{(s)} + H_2O_{(1)} \rightarrow Ca(OH)_{2(s)}$
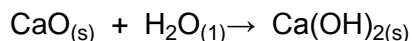
       (i)   Give the chemical name of $Ca(OH)_2$.
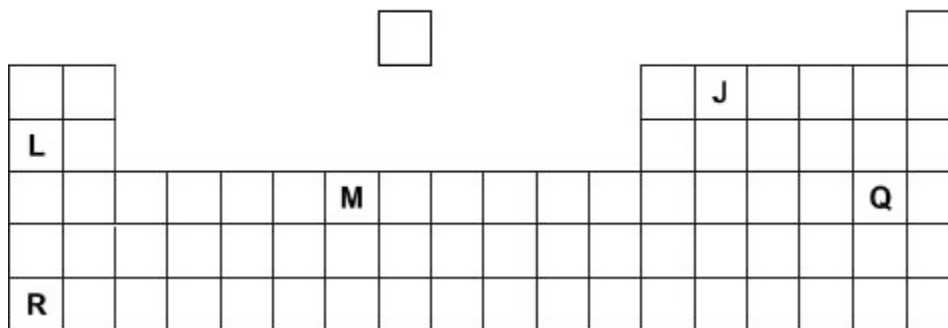
       _____

(1)

       (ii)   What is the physical state of the $Ca(OH)_2$ formed in the reaction?

       _____

(1)
(Total 8 marks)

5 **Figure 1** shows an outline of the modern periodic table.

Figure 1

J, **L**, **M**, **Q** and **R** represent elements in the periodic table.

(a)   Which element has four electrons in its outer shell?

Tick (✓) **one** box.

J ☐   L ☐   M ☐   Q ☐   R ☐

(1)

(b)   Which **two** elements in **Figure 1** are in the same period?

_____ and _____

(1)

(c)   Which element reacts with potassium to form an ionic compound?

Tick (✓) **one** box.

J ☐   L ☐   M ☐   Q ☐   R ☐

(1)

(d)   Which element forms ions with different charges?

Tick (✓) **one** box.

J ☐   L ☐   M ☐   Q ☐   R ☐

(1)

(e) Which element has three electron shells?

Tick (✓) **one** box.

J ☐   L ☐   M ☐   Q ☐   R ☐

(1)

(f) In the 1860s scientists were trying to organise elements.

Figure 2 shows the table published by John Newlands in 1865.

The elements are arranged in order of their atomic weights.

Figure 2

H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Ti	Mn	Fe
Co,Ni	Cu	Zn	Y	In	As	Se
Br	Rb	Sr	Ce,La	Zr	Di,Mo	Ro,Ru
Pd	Ag	Cd	U	Sn	Sb	Te

Figure 3 shows the periodic table published by Dmitri Mendeleev in 1869.

Figure 3

H							
Li	Be	B	C	N	O	F	
Na	Mg	Al	Si	P	S	Cl	
K Cu	Ca Zn	? ?	Ti ?	V As	Cr Se	Mn Br	Fe Co Ni
Rb Ag	Sr Cd	Y In	Zr Sn	Nb Sb	Mo Te	? I	Ru Rh Pd

Mendeleev's table became accepted by other scientists whereas Newlands' table was not.

Evaluate Newlands' and Mendeleev's tables.

You should include:

•   a comparison of the tables

•   reasons why Mendeleev's table was more acceptable.

Use **Figure 2** and **Figure 3** and your own knowledge.

(6)
(Total 11 marks)

Mark schemes

1 (a) FeS_2

> *do **not** accept equations*

1

(b) 26

1

30

1

26

1

> *must be this order*

(c) any **two** from:
- iron has a high(er) melting / boiling point
- iron is dense(r)
- iron is hard(er)

> *allow iron is less malleable / ductile*

- iron is strong(er)
- iron is less reactive

> *allow specific reactions showing difference in reactivity*

- iron has ions with different charges
- iron forms coloured compounds
- iron can be a catalyst

> *allow iron is magnetic*
>
> *allow the converse statements for sodium*
>
> *allow transition metal for iron*
> *allow Group 1 metal for sodium*
>
> *ignore references to atomic structure*
>
> *ignore iron rusts*

2

(d) carbon is more reactive (than nickel)

> *allow converse*

1

(so) carbon will displace / replace nickel (from nickel oxide)

> *allow (so) nickel ions gain electrons*

or
(so) carbon will remove oxygen (from nickel oxide)

> *allow (so) carbon transfers electrons to nickel (ions)*

1

(e)   (total M_r of reactants =) 87

1

(percentage atom economy)

$$= \frac{59}{87} \times 100$$

allow (percentage atom economy)

$$= \frac{59}{in\,correctly\,calculated\,M_r} \times 100$$

1

= 67.8 (%)

allow an answer from an incorrect calculation to 3 sig figs

1

*an answer of 67.8 (%) scores **3** marks*

*an answer of 67.8160919 (%) or correctly rounded answer to 2, 4 or more sig figs scores **2** marks*

an incorrect answer for one step does not prevent allocation of marks for subsequent steps

[11]

2   (a)   solid (zinc chloride) does not conduct (electricity)
or
zinc chloride needs to be in solution **or** molten

allow liquid / aqueous

1

(because) ions cannot move in the solid
or
(as) ions can (only) move in liquid / solution

*do **not** accept references to movement of electrons in zinc chloride*

1

(b)   each carbon / atom forms 3 (covalent) bonds

1

one electron per carbon / atom is delocalised

1

(so) these electrons carry charge through the graphite
or
(so) these electrons move through the structure

ignore carry current / electricity

1

*if no other mark scored, allow **1** mark for delocalised / free electrons*

allow free electrons for delocalised electrons

(c)   use measuring cylinders (instead of test tubes)

        allow use burettes

        allow use (gas) syringes

        allow Hoffmann voltameter

1

(because) test tubes cannot measure volume
or
(because) test tubes have no graduations / scale

        allow (so that) volume can be measured

1

(d)   any **three** from:

- the volume of hydrogen collected is directly proportional to the time

        allow the (volume of) hydrogen is collected at a constant / steady rate

- the rate of collection of hydrogen is 0.45 (cm^3/min)

- up to 8 minutes chlorine is collected at an increasing rate

        allow any value from 6 to 8 minutes

        allow initially chlorine is collected at an increasing rate

- after 8 minutes the rate of collection of chlorine is the same as that of hydrogen

        allow any value from 6 to 8 minutes

        or
after 8 minutes the rate of collection of chlorine is 0.45 (cm^3/min)

        allow after 8 minutes the (volume of) chlorine is collected at a constant / steady rate

        *if neither bullet point 3 nor bullet point 4 is awarded allow **1** mark for chlorine is collected slowly up to 8 minutes and then more quickly*

        allow any value from 6 to 8 minutes

3

(e)   chlorine reacts with water
or
chlorine dissolves (in the solution).

1

(f)   (volume =) $\dfrac{6.6}{1000}$ (dm^3)

or 0.0066 (dm^3)

> *allow 6.5 (cm^3) for 6.6 (cm^3)*

1

(moles =) $\dfrac{0.0066}{24}$

> *allow use of incorrect volume from step 1*

1

= 2.75 × 10^{-4} (mol)

> *allow 2.8 × 10^{-4} (mol)*
>
> *allow answer from incorrect calculation given in standard form*
>
> *alternative approach for marking points 1 and 2*
>
> *24 dm^3 = 24 000 cm^3 (1)*
>
> (moles =) $\dfrac{6.6}{24\,000}$ *(1)*

1

> *an answer of 2.75 × 10^{-4} (mol) or 2.8 × 10^{-4} (mol) scores 3 marks*
>
> *an answer of 0.000275 / 0.00028 / 2.75 × 10^{-1} / 2.8 × 10^{-1} (mol) / scores 2 marks*
>
> *an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps*
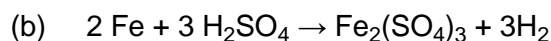
[10]

3 (a)   10.86

> *accept answers between 10.64 to 10.9*
>
> *if answer is incorrect allow 1 mark for*
> *rfm FeSO$_4$ = 152*
> *2 marks for 152 × 4/56*

3

(b)   2 Fe + 3 H$_2$SO$_4$ → Fe$_2$(SO$_4$)$_3$ + 3H$_2$

> *accept other correct multiples for balancing*

1

[4]

4 (a)   40 + 12 + (3 × 16) = 100

> *each for 1 mark*

2

(b) M_r of CaO = 56

for 1 mark

mass required = 60 × 100/56

for 2 marks

= 107.1

for 1 mark

4

(c)   (i)   calcium hydroxide

1

(ii)   solid

1

[8]

5   (a)   **J**

1

(b)   **M** and **Q**

either order

1

(c)   **Q**

1

(d)   **M**

1

(e)   **L**

1

(f) **Level 3 (5-6 marks):**
A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.

Level 2 (3-4 marks):
Some logically linked reasons are given. There may also be a simple judgement.

Level 1 (1-2 marks):
Relevant points are made. They are not logically linked.

Level 0
No relevant content

Indicative content

comparative points
- both tables have more than one element in a box
- both have similar elements in the same column
- both are missing the noble gases
- both arranged elements in order of atomic weight

advantages of Mendeleev / disadvantages of Newlands
- Newlands did not leave gaps for undiscovered elements
- Newlands had many more dissimilar elements in a column
- Mendeleev left gaps for undiscovered elements
- Mendeleev changed the order of some elements (e.g. Te and I)

points which led to the acceptance of Mendeleev's table
- Mendeleev predicted properties of missing elements
- elements with properties predicted by Mendeleev were discovered
- Mendeleev's predictions turned out to be correct
- elements were discovered which fitted the gaps

6

[11]