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

Q1.

This question is about iron.

(a) Iron is a metal.

Describe how iron conducts thermal energy.

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(2)

(b) Pure iron is too soft for many uses.

Explain why mixing iron with other metals makes alloys which are harder than pure iron.

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(3)

(c) When iron reacts with chlorine, 0.12 mol of iron reacts with 0.18 mol of chlorine (Cl_2).

Which is the correct equation for the reaction? **(HT only)**

Tick (✓) **one** box.

$Fe + Cl_2 \rightarrow FeCl_2$ ☐

$Fe + 3\ Cl_2 \rightarrow FeCl_6$ ☐

$2\ Fe + Cl_2 \rightarrow 2\ FeCl$ ☐

$2\ Fe + 3\ Cl_2 \rightarrow 2\ FeCl_3$ ☐

(1)

The most common oxides of iron are Fe_2O_3 and Fe_3O_4

(d) What is the ratio of the numbers of ions in Fe_3O_4?

Tick (✓) **one** box.

$2\ Fe^{2+} : 1\ Fe^{3+} : 4\ O^{2-}$ ☐

$1\ Fe^{2+} : 2\ Fe^{3+} : 4\ O^{2-}$ ☐

$3\ Fe^{2+} : 4\ O^{2-}$ ☐

$3\ Fe^{3+} : 4\ O^{2-}$ ☐

(1)

(e) Calculate the percentage (%) by mass of iron in Fe_3O_4

Relative atomic masses (A_r): O = 16 Fe = 56

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Percentage by mass of iron = _____ %

(3)

(f) Fe_2O_3 reacts with carbon to produce carbon dioxide.

The equation for the reaction is:

$$2\ Fe_2O_3(s) + 3\ C(s) \rightarrow 4\ Fe(s) + 3\ CO_2(g)$$

Calculate the volume of carbon dioxide gas at room temperature and pressure that is produced from 40.0 kg of Fe_2O_3 using excess carbon. **(chemistry only) (HT only)**

Relative formula mass (M_r): $Fe_2O_3 = 160$

The volume of 1 mole of any gas at room temperature and pressure is 24 dm^3.

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Volume of carbon dioxide = _____ dm^3

(5)

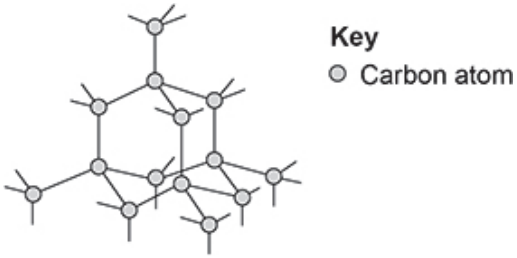
(Total 15 marks)

Q2.

This question is about different forms of carbon.

Figure 1 represents the structure of diamond.

Figure 1



(a) Describe the structure and bonding of diamond.

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(3)

(b) Explain why diamond has a very high melting point.

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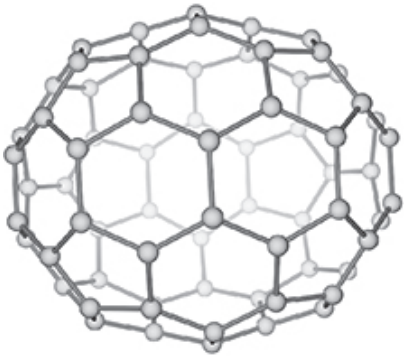
(3)

Figure 2 represents the molecule C_{70}

Figure 2



(c) What is the name of this type of molecule?

Tick (✓) **one** box.

Fullerene ☐

Graphene ☐

Nanotube ☐

Polymer ☐

(1)

(d) Molecules such as C_{70} can be used in medicine to move drugs around the body.

Suggest **one** reason why the C_{70} molecule is suitable for this use.

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_____

(1)

(e) Calculate the number of C_{70} molecules that can be made from one mole of carbon atoms. **(HT only)**

The Avogadro constant = 6.02×10^{23} per mole

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Number of molecules = _____

(3)

(Total 11 marks)

Q3.

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.

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(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.

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(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.

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(1)

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

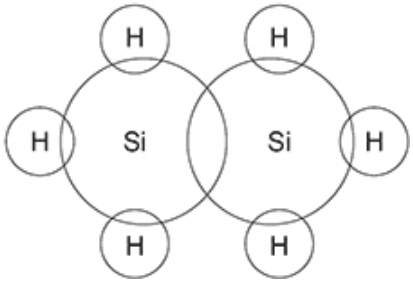
Relative atomic masses (A_r): O = 16 Mg = 24 Si = 28

Minimum mass of magnesium = _____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:

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

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.

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Volume of gases = _____ cm^3

(4)

(Total 15 marks)