**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)**

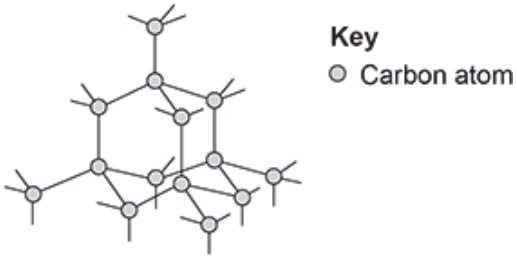
**(Total 15 marks)**

## 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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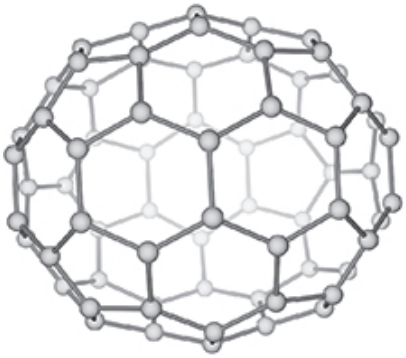
**(3)**

**Figure 2** represents the molecule $C_{70}$

**Figure 2**



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

Tick (✓) **one** box.

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|---|---|
| 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 = $6.02 \times 10^{23}$ 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)**

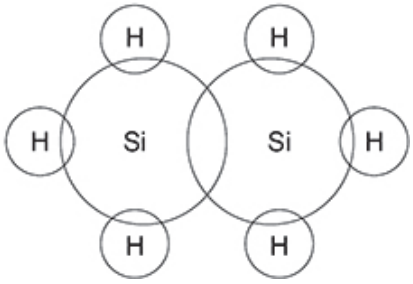
Relative atomic masses ($A_r$): O = 16 Mg = 24 Si = 28

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)**