

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.

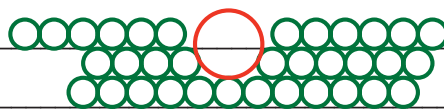
Thermal energy is conducted or transferred by delocalised electrons.

(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.

The alloy mixture has different sized atoms so the layers are distorted and cannot easily slide over each other.

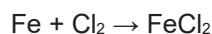


(3)

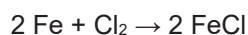
- (c) When iron reacts with chlorine, 0.12 mol of iron reacts with 0.18 mol of chlorine (Cl_2).

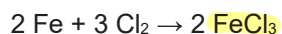
Which is the correct equation for the reaction? (HT only)

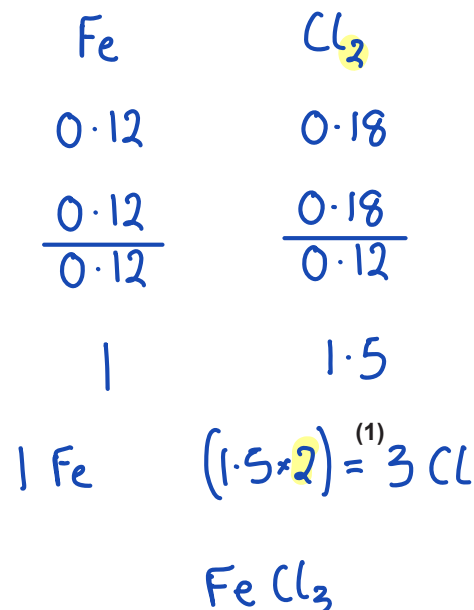
Tick (✓) **one** box.











3.2 Use of Amount of Substance on Pure Substances (H)

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-}



$$\text{Negative charge} = 4 \times \text{O}^{2-} = -8$$

$$\text{Total Positive charge} = +8$$

Fe can be $+2$ or $+3$

$$2 \text{Fe}^{3+} + \text{Fe}^{2+} = 8+$$

$$\therefore \text{Fe}^{2+} : \text{Fe}^{3+} : \text{O}^{2-} \\ 1 : 2 : 4 \quad (1)$$

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

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

$$M_r(\text{Fe}_3\text{O}_4) = (3 \times 56) + (4 \times 16) = 232 \text{ g mol}^{-1}$$

$$\text{Mass of Fe} = (3 \times 56) = 168 \text{ g mol}^{-1}$$

$$\% \text{ Fe} = \frac{168}{232} \times 100 \\ = 72.4\%$$

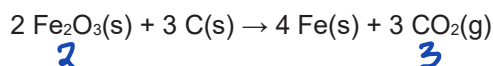
Percentage by mass of iron = 72.4 %

(3)

3.2 Use of Amount of Substance on Pure Substances (H)

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

The equation for the reaction is:

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): $\text{Fe}_2\text{O}_3 = 160$ The volume of 1 mole of any gas at room temperature and pressure is 24 dm^3 .

$$\begin{aligned} \text{Amount of } \text{Fe}_2\text{O}_3 &= 40.0 \text{ kg} = 40\,000 \text{ g} \\ n(\text{Fe}_2\text{O}_3) &= \frac{40\,000 \text{ g}}{160 \text{ g mol}^{-1}} = 250 \text{ mol} \\ 2 \text{Fe}_2\text{O}_3 &\text{ produces } 3 \text{ mol CO}_2 \\ n(\text{CO}_2) &= 250 \text{ mol} \times \frac{3}{2} = 375 \text{ mol} \\ \text{Vol. CO}_2 &= 375 \text{ mol} \times 24 \text{ dm}^3 \text{ mol}^{-1} \\ &= 9000 \text{ dm}^3 \end{aligned}$$

Volume of carbon dioxide = 9000 dm^3

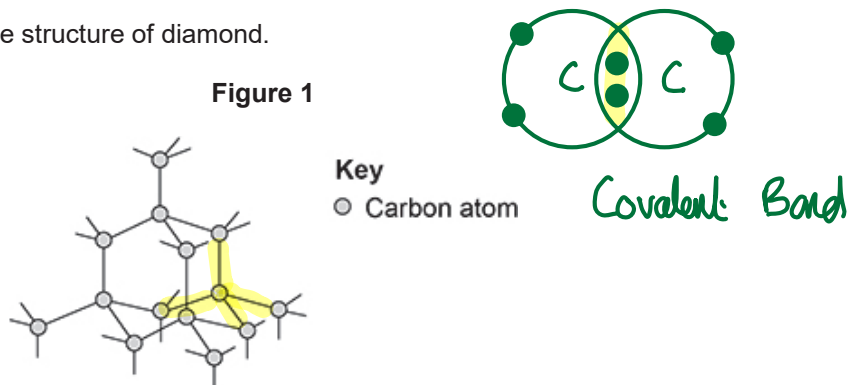
(5)

(Total 15 marks)

Q2.

This question is about different forms of carbon.

Figure 1 represents the structure of diamond.



- (a) Describe the structure and bonding of diamond.

Each carbon is covalently bonded to 4 neighbouring carbons, forming a giant covalent structure.

(3)

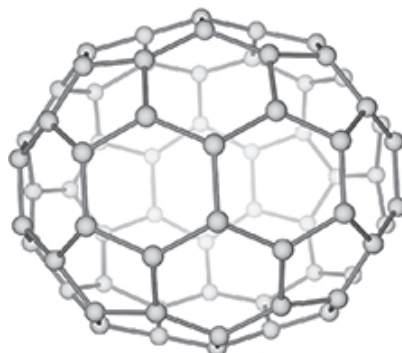
- (b) Explain why diamond has a very high melting point.

Covalent bonds are strong
Many bonds in the giant covalent structure need to be broken,
so a lot of energy is needed
thus a very high melting point.

(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.

C_{70} acts as a cage to carry the drug around the body. It is also unreactive and non-toxic.

(1)

3.2 Use of Amount of Substance on Pure Substances (H)

- (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

$$\text{Number of C atoms in 1 mole} = 6.02 \times 10^{23} \text{ atoms}$$

$$\text{Number of C atoms in 1 } C_{70} = 70 \text{ atoms}$$

$$\text{Number of } C_{70} \text{ molecules} = \frac{6.02 \times 10^{23} \text{ atoms}}{70 \text{ atoms}}$$

$$\text{that can be made}$$

$$= 8.6 \times 10^{21}$$

$$\text{Number of molecules} = 8.6 \times 10^{21}$$

(3)

(Total 11 marks)

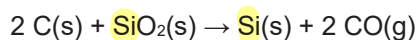
Q3.

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:



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

Carbon displaces Silicon from SiO_2
 So Silicon is less reactive than Carbon
 (Si is below C in the reactivity series)

(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.

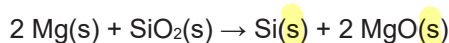
Explain why aluminium is more expensive than carbon.

Aluminium is obtained from Aluminium oxide by electrolysis.
 So more energy is needed to obtain Aluminium

(2)

Magnesium also reduces silicon dioxide.

The equation for the reaction is:

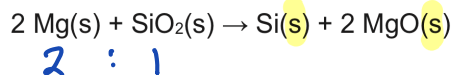


- (c) Give **one** reason why the products are difficult to separate if magnesium is used to reduce silicon dioxide.

Both products (Si and MgO) are solid.

(1)

3.2 Use of Amount of Substance on Pure Substances (H)



- (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

$$M_r(\text{SiO}_2) = 28 + (2 \times 16) = 60 \text{ g mol}^{-1}$$

$$\text{Amount: SiO}_2 = 1.2 \text{ kg} = 1200 \text{ g}$$

$$n(\text{SiO}_2) = \frac{1200 \text{ g}}{60 \text{ g mol}^{-1}} = 20 \text{ mol}$$

2 Mg needed to reduce 1 mole SiO_2

$$N^\circ \text{ mol Mg} = 20 \text{ mol} \times 2 = 40 \text{ mol}$$

$$\begin{aligned} \text{Mass Mg} &= 40 \text{ mol} \times 24 \text{ g mol}^{-1} \\ &= 960 \text{ g} \end{aligned}$$

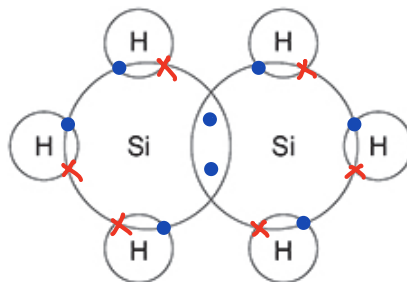
Minimum mass of magnesium = 960 g

(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

Si = Group 4

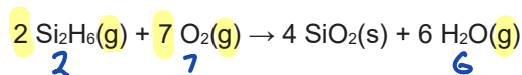


(1)

3.2 Use of Amount of Substance on Pure Substances (H)

- (f)
- Si_2H_6
- reacts with oxygen.

The equation for the reaction is:

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.

$$1 \text{ mol gas at RTP} = 24 \text{ dm}^3$$

$$\text{Volume of } \text{Si}_2\text{H}_6 \text{ used} = 30 \text{ cm}^3$$

$$\text{Volume of } \text{O}_2 \text{ needed} = 30 \times \frac{7}{2} = 105 \text{ cm}^3$$

$$\text{Volume of } \text{O}_2 \text{ left over} = 150 - 105 = 45 \text{ cm}^3$$

$$\text{Volume of } \text{H}_2\text{O}(\text{g}) \text{ produced} = 30 \times \frac{6}{2} = 90 \text{ cm}^3$$

$$\text{Volume of gases present after reaction (O}_2 + \text{H}_2\text{O)} = 45 + 90 = 135 \text{ cm}^3$$

$$\text{Volume of gases} = 135 \text{ cm}^3$$

(4)

(Total 15 marks)