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.

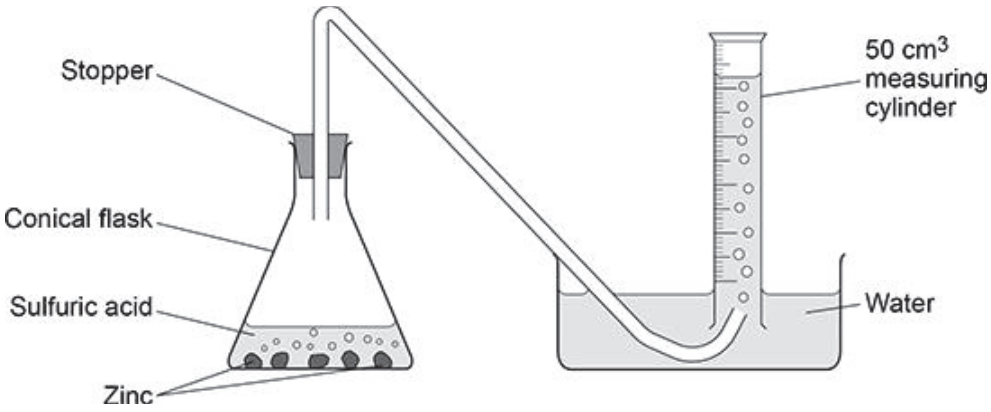
A student investigated the rate of the reaction between zinc and sulfuric acid.

The equation for the reaction is

$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Pour 50 cm^3 of sulfuric acid into the conical flask.
2. Add excess zinc to the conical flask.
3. Insert the stopper and start a timer.
4. Measure the volume of hydrogen collected in the 50 cm^3 measuring cylinder every 20 seconds for 180 seconds.

(a) Explain why the volume of hydrogen collected in the 50 cm^3 measuring cylinder is less than the volume of hydrogen produced.

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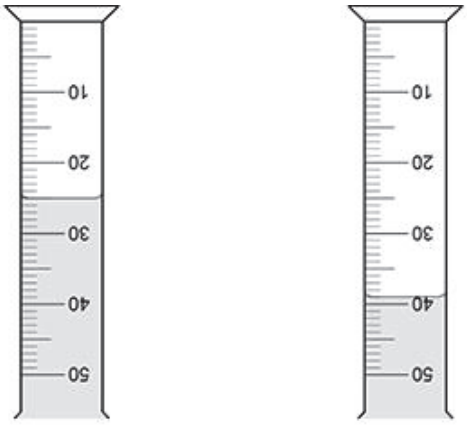
(2)

Figure 2 shows the volumes of hydrogen collected in the 50 cm^3 measuring cylinder after 40 seconds and after 100 seconds.

Figure 2



40 seconds 100 seconds

(b) Determine the number of moles of hydrogen collected between 40 seconds and 100 seconds. **(chemistry only) (HT only)**

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

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Moles of hydrogen = _____

(4)

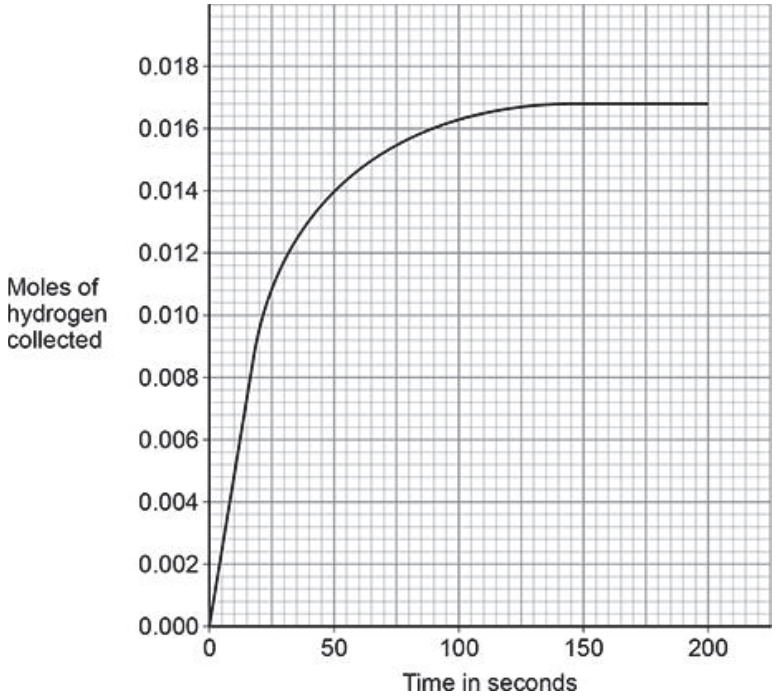
A different student investigated how the concentration of sulfuric acid affected the rate of the reaction.

(c) The student did a different experiment using sulfuric acid of concentration 0.40 mol/dm^3.

The student calculated the number of moles of hydrogen collected after every 20 seconds.

Figure 3 shows the results.

Figure 3



Determine the rate of reaction at 45 seconds.

You should draw a tangent on **Figure 3**.

Give your answer in standard form. **(HT only)**

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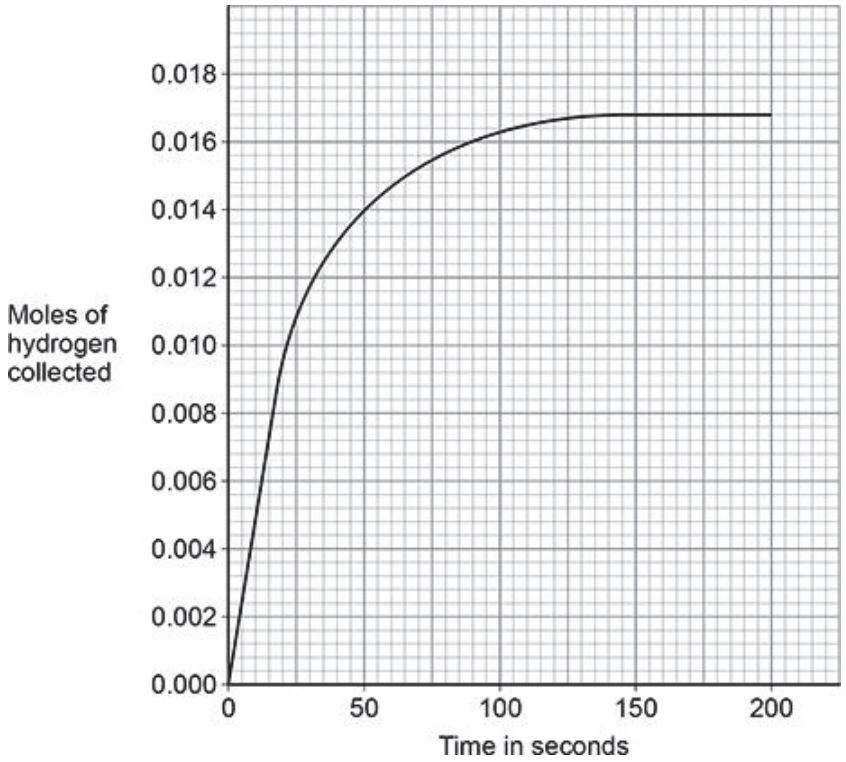
Rate of reaction (in standard form) = _____ mol/s

(5)

(d) **Figure 4** shows the results for 0.40 mol/dm^3 sulfuric acid.

Figure 4



The student repeated the experiment using 0.20 mol/dm^3 sulfuric acid instead of 0.40 mol/dm^3 sulfuric acid.

Excess zinc was used in each experiment.

Sketch a line on **Figure 4** to show the results you would expect.

(2)

(e) Explain how increasing the temperature would affect the rate of reaction between zinc and sulfuric acid.

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(3)

(Total 16 marks)

Q3.

This question is about titanium dioxide (TiO_2).

(a) Self-cleaning windows are coated with a layer of nanoparticles of titanium dioxide.

Titanium dioxide:

- helps sunlight break down dirt particles
- attracts water, so dirt is washed away by rain.

Nanoparticles of titanium dioxide are used instead of fine particles of titanium dioxide for coating self-cleaning windows.

Suggest **two** reasons why. **(chemistry only)**

1 _____

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2 _____

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(2)

(b) Titanium is extracted from titanium dioxide in a two-stage process.

The equation for the first stage in the process is:

$$TiO_2 + 2\ Cl_2 + 2\ C \rightarrow TiCl_4 + 2\ CO$$

Calculate the volume of chlorine gas needed to react completely with 100 kg of titanium dioxide. **(chemistry only) (HT only)**

Relative atomic masses (A_r): O = 16 Ti = 48

The volume of one mole of gas = 24 dm^3

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Volume = _____ dm^3

(6)

(Total 8 marks)

Q4.

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

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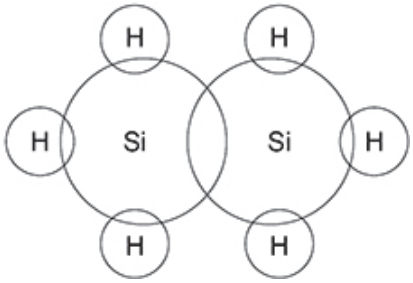
Minimum mass of magnesium = _____g

(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)