4 Methane and steam react to produce hydrogen.

$$CH_4(g) + 2H_2O(g) \rightarrow CO_2(g) + 4H_2(g)$$

0.80 g of methane and 1.35 g of steam react. One of the reactants is used up.

Which volume of hydrogen, measured at room conditions, will be produced?

A $1.80\,dm^3$ **B** $3.60\,dm^3$ **C** $4.80\,dm^3$ **D** $7.20\,dm^3$

A-Level Chemistry: **w25 14**

4 A solution containing 4.4 g of an organic acid is exactly neutralised by $25.0\,cm^3$ of $2.0\,mol\,dm^{-3}$ sodium hydroxide. The acid has one COOH group in each molecule.

What is the empirical formula of the acid?

A CH_2O **B** C_2H_4O **C** $C_3H_6O_3$ **D** $C_4H_8O_2$

1 Hydrated ethanedioic acid is a diprotic acid with the formula $(COOH)_2 \cdot \mathbf{x}H_2O$ where **x** is an integer.

Ethanedioic acid reacts with manganate(VII) ions when heated.

$$5(COOH)_2(aq) + 2MnO_4^-(aq) + 6H^+(aq) \rightarrow 10CO_2(g) + 2Mn^{2+}(aq) + 8H_2O(l)$$

You will determine the value of **x** in $(COOH)_2 \cdot \mathbf{x}H_2O$ by titrating a solution containing ethanedioic acid with manganate(VII) ions.

- **FA 1** is $6.20\,g\,dm^{-3}$ aqueous ethanedioic acid, $(COOH)_2 \cdot \mathbf{x}H_2O$.
- **FA 2** is $0.0200\,mol\,dm^{-3}$ potassium manganate(VII), $KMnO_4$.
- **FA 3** is $1.0\,mol\,dm^{-3}$ sulfuric acid, H_2SO_4.

(a) Method

- Fill the burette with **FA 2**.
- Pipette $25.0\,cm^3$ of **FA 1** into a conical flask.
- Use the measuring cylinder to add approximately $20\,cm^3$ of **FA 3** to the conical flask.
- Place the conical flask on a tripod and gauze and heat carefully until the temperature of the solution is approximately 70 °C.
- Remove the flame.
- Carefully lift the hot conical flask and place it on the white tile under the burette.
- Add **FA 2** drop-wise for the first $2–3\,cm^3$. Any initial pink colouring may take several seconds to disappear.
- If the reaction mixture turns brown, reheat it to about 70 °C. If the brown colour disappears, continue the titration. If the brown colour remains, discard the contents of the flask and begin a new titration.
- The end-point is reached when a permanent pale pink colour is formed.
- Perform a rough titration with **FA 2**. Record your burette readings in the space below.

The rough titre is .... cm^3.

- Carry out as many titrations as you think necessary to obtain consistent results.
- Make sure any recorded results show the precision of your practical work.
- Record all your burette readings and the volume of **FA 2** added in each accurate titration.

Results

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results, calculate a suitable mean value to be used in your calculations.

Show clearly how you obtained this value.

25.0 cm^3 of **FA 1** required .... cm^3 of **FA 2**. [1]

(c) Calculations

(i) Give your answers to **(c)(ii)**, **(c)(iii)** and **(c)(iv)** to the appropriate number of significant figures. [1]

(ii) Calculate the amount, in mol, of manganate(VII) ions, MnO_4^-, in the volume of **FA 2** calculated in **(b)**.

amount of MnO_4^- = ... mol [1]

(iii) Calculate the amount, in mol, of ethanedioic acid that reacts with the manganate(VII) ions in **(c)(ii)**.

amount of $(COOH)_2$ = ... mol

Hence calculate the concentration, in mol dm^{-3}, of ethanedioic acid in **FA 1**.

concentration of $(COOH)_2$ = ... mol dm^{-3} [2]

(iv) Calculate the relative molecular mass, M_r, of the ethanedioic acid in **FA 1**.

M_r = ... [1]

(v) Calculate the value of **x** in $(COOH)_2 \cdot xH_2O$.

Show your working.

x = ... [1]

(d) Explain why it is necessary to add **FA 3** in each titration.

....

.... [1]

[Total: 15]

2 Hydrated zinc sulfate has the formula $ZnSO_4 \cdot \mathbf{y}H_2O$ where **y** is an integer.

Hydrated zinc sulfate decomposes when heated, losing only its water of crystallisation and becoming anhydrous.

You will determine the value of **y** in $ZnSO_4 \cdot \mathbf{y}H_2O$ by heating the hydrated salt until it becomes anhydrous.

FA 4 is hydrated zinc sulfate, $ZnSO_4 \cdot \mathbf{y}H_2O$.

(a) Method

- Weigh the crucible with its lid. Record the mass in the space for Results.
- Add between 3.20 g and 3.40 g of **FA 4** to the crucible.
- Weigh the crucible with its lid and **FA 4**. Record the mass.
- Place the crucible on the pipeclay triangle. Gently heat the crucible and contents for approximately 2 minutes with the lid on.
- Remove the lid. Heat the crucible and contents strongly for approximately 4 minutes.
- Replace the lid and leave the crucible and residue to cool for at least 5 minutes.

You may wish to begin work on Question 3 while the crucible is cooling.

- Weigh the crucible with its lid and its contents. Record the mass.
- Remove the lid. Heat the crucible strongly for approximately 3 minutes.
- Replace the lid and leave the crucible and residue to cool for at least 5 minutes.
- Weigh the crucible with its lid and its contents. Record the mass.
- Calculate the mass of **FA 4** used and the mass of residue obtained. Record the masses.

Results

I	
II	
III	
IV	
V	

[5]

(b) Calculations

(i) Calculate the amount, in mol, of anhydrous zinc sulfate residue formed in the decomposition of **FA 4**.

amount of $ZnSO_4$ = ... mol

Calculate the amount, in mol, of water of crystallisation lost.

amount of H_2O = ... mol
[2]

(ii) Calculate the value of **y** in the formula $ZnSO_4 \cdot \mathbf{y}H_2O$.

Show your working.

y = ... [2]

(c) A student suggests using this thermal decomposition method to investigate the number of moles of water of crystallisation in hydrated ethanedioic acid. The teacher says that this method is unsuitable.

Suggest why this method is unsuitable.

....

.... [1]

[Total: 10]

Qualitative analysis

For each test you should record all your observations in the spaces provided.

Examples of observations include:
- colour changes seen
- the formation of any precipitate and its solubility (where appropriate) in an excess of the reagent added
- the formation of any gas and its identification (where appropriate) by a suitable test.

You should record clearly at what stage in a test an observation is made.

Where no change is observed, you should write 'no change'.

Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.

If any solution is warmed, a boiling tube must be used. If a solid is heated, a hard-glass test-tube must be used.

Rinse and reuse test-tubes and boiling tubes where possible.

No additional tests should be attempted.

2 In this experiment you will determine the percentage by mass of a sodium halide impurity present in a sample of sodium hydrogencarbonate by titration.

$$NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) + CO_2(g)$$

FB 4 is an aqueous solution made by dissolving 17.20 g of the impure sodium hydrogencarbonate in each dm^3 of solution.
FB 5 is 0.200 mol dm^{-3} hydrochloric acid, HCl.
FB 6 is methyl orange indicator.

(a) Method

- Fill the burette with **FB 5**.
- Pipette 25.0 cm^3 of **FB 4** into a conical flask.
- Add several drops of **FB 6** to the conical flask.
- Perform a rough titration and record your burette readings in the space below.

The rough titre is .... cm^3.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make sure any recorded results show the precision of your practical work.
- Record all your burette readings and the volume of **FB 5** added in each accurate titration.

Keep FB 4 for use in Question 3.

Results

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results, calculate a suitable mean value to be used in your calculations.
Show clearly how you obtained this value.

25.0 cm^3 of **FB 4** required .... cm^3 of **FB 5**. [1]

(c) Calculations

(i) Give your answers to **(c)(ii)** and **(c)(iii)** to an appropriate number of significant figures. [1]

(ii) Use your answer to **(b)** to calculate the amount, in mol, of hydrochloric acid in your mean titre.

amount of HCl = ... mol

Hence determine the amount, in mol, of sodium hydrogencarbonate present in 25.0 cm^3 of **FB 4**.

amount of $NaHCO_3$ = ... mol
[1]

(iii) Calculate the mass of sodium hydrogencarbonate present in each dm^3 of solution.

mass of $NaHCO_3$ = ... g

Hence calculate the percentage by mass of the sodium halide impurity in **FB 4**.
Show your working.

percentage by mass = ... %
[2]

(d) A student carries out the experiment in Question 1 using the impure sodium hydrogencarbonate dissolved to make **FB 4**.
State how this affects the value of ΔH_1 determined in **1(b)(iii)** compared to the value the student would get if pure sodium hydrogencarbonate were used.

....

....

State what assumption you have made about the sodium halide impurity.

....

....
[2]

[Total: 14]

Qualitative analysis

For each test you should record all your observations in the spaces provided.

Examples of observations include:
- colour changes seen
- the formation of any precipitate and its solubility (where appropriate) in an excess of the reagent added
- the formation of any gas and its identification (where appropriate) by a suitable test.

You should record clearly at what stage in a test an observation is made.

Where no change is observed, you should write ‘no change’.

Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.

If any solution is warmed, a boiling tube must be used. If any solid is heated a hard-glass test-tube must be used.

Rinse and reuse test-tubes and boiling tubes where possible.

No additional tests should be attempted.

1 The concentration of aqueous chloride ions can be found by titration with aqueous silver nitrate, $AgNO_3(aq)$.

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

The indicator used is aqueous potassium chromate(VI), $K_2CrO_4(aq)$.

As $AgNO_3(aq)$ is added to aqueous chloride ions, a white precipitate of $AgCl(s)$ is formed.

When all the chloride ions have reacted, further addition of $AgNO_3(aq)$ leads to the formation of a red precipitate of silver chromate(VI), $Ag_2CrO_4(s)$. The first appearance of the red precipitate shows the end-point of the titration.

A student carries out an experiment to determine the number of molecules of water of crystallisation, *x*, in hydrated barium chloride, $BaCl_2{\bullet}xH_2O(s)$.

(a) The student makes 250.0 cm^3 of 0.0500 $mol\,dm^{-3}$ $AgNO_3(aq)$ to use for the titration.

(i) Calculate the mass of solid silver nitrate, $AgNO_3(s)$, needed to make 250.0 cm^3 of 0.0500 $mol\,dm^{-3}$ $AgNO_3(aq)$.

Give your answer to **two** decimal places.

mass of $AgNO_3(s)$ = ... g [1]

(ii) Describe how the student should make 250.0 cm^3 of 0.0500 $mol\,dm^{-3}$ $AgNO_3(aq)$ starting from the mass of $AgNO_3(s)$ calculated in **(a)(i)** in a 50 cm^3 beaker.

Give the name and size of any key apparatus used.

Write your answer using a series of numbered steps.

....

....

....

....

....

....

.... [3]

(b) The student uses the following method.

step 1 Dissolve 1.58 g of $BaCl_2{\bullet}xH_2O(s)$ to form 250 cm^3 of aqueous solution. Label this solution **A**.

step 2 Transfer 20.0 cm^3 of solution **A** into a conical flask.

step 3 Add aqueous sodium sulfate, $Na_2SO_4(aq)$, to the flask and swirl the mixture to remove barium ions from the solution.

step 4 Add 2–3 drops of $K_2CrO_4(aq)$ indicator to the flask.

step 5 Titrate the contents of the flask against 0.0500 $mol\,dm^{-3}$ $AgNO_3(aq)$.

step 6 Repeat steps 2 to 5 to collect sufficient data for analysis.

(i) Suggest a suitable piece of apparatus for transferring 20.0 cm^3 of solution **A** in step 2.

.... [1]

(ii) Suggest why barium ions are removed in step 3 before performing the titration.

....

.... [1]

(iii) Suggest why chemically resistant gloves should be worn to carry out step 4.

.... [1]

(c) The student's results are shown in Table 1.1.

Table 1.1

	rough titration	titration 1	titration 2	titration 3
burette reading (final) / cm^3	20.10	40.55	20.75	20.90
burette reading (initial) / cm^3	0.00	20.25	0.05	0.30
titre / cm^3	20.10	20.30	20.70	20.60

The student uses the titres from titrations 2 and 3 shown in Table 1.1 to calculate a mean titre value of 20.65 cm^3.

(i) Explain why only these two values are used.

.... [1]

(ii) Calculate the percentage error in the titre volume for titration 3.
Show your working.

percentage error = ... [1]

(d) The equation for the reaction of silver nitrate with barium chloride is shown.

$$2AgNO_3(aq) + BaCl_2(aq) \rightarrow Ba(NO_3)_2(aq) + 2AgCl(s)$$

(i) Calculate the amount, in mol, of $AgNO_3$(aq) in the mean titre of 20.65 cm^3.

amount of $AgNO_3$ = ... mol [1]

(ii) Calculate the amount, in mol, of $BaCl_2$(aq) in 250 cm^3 of solution **A**.

amount of $BaCl_2$ = ... mol [1]

(iii) Calculate the value of *x* in the formula $BaCl_2 \bullet xH_2O$.

x = ... [2]

(e) Another student uses a different experimental method to check the value of *x* obtained by the method described in **(b)**.

Give a **brief** description of another method, not involving titration, that could be used to determine the value of *x* in the formula $BaCl_2 \bullet xH_2O$(s). Write your answer using a series of numbered steps.

Your plan should include details of the following:
- the apparatus and method you would use
- the measurements you would make.

You are provided with standard laboratory apparatus.

....

....

....

....

....

....

....

....

.... [3]

[Total: 16]

2 A student carries out an experiment to determine the concentration of aqueous sulfate ions, $SO_4^{2-}(aq)$, in a sample of lake water.

(a) The student uses the following method.

step 1 Transfer 25.00 cm^3 of the lake water sample to a beaker and record its conductivity as shown in Fig. 2.1.

step 2 Add 5.00 cm^3 of 0.100 mol dm^{-3} aqueous barium hydroxide, $Ba(OH)_2(aq)$, to the beaker.

step 3 Stir the mixture and record the conductivity of the contents of the beaker as shown in Fig. 2.1.

step 4 Repeat steps 2 and 3 until a total of 40.00 cm^3 of 0.100 mol dm^{-3} $Ba(OH)_2(aq)$ has been added to the beaker.

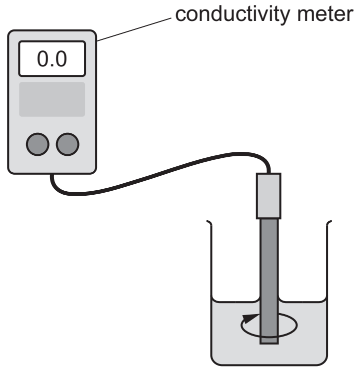

Fig. 2.1

(i) Suggest a suitable piece of apparatus to transfer 25.00 cm^3 of the lake water sample to the beaker in step 1.

.... [1]

(ii) 0.100 mol dm^{-3} $Ba(OH)_2(aq)$ is an irritant to skin and eyes. Other than wearing safety goggles, state **one** safety precaution that the student should take when conducting this experiment.

.... [1]

(b) The student's results are given in Table 2.1.

A correction can be applied to the conductivity values to take into account dilution of the solution as its volume increases using the following equation.

$$\text{corrected conductivity} = \text{measured conductivity} \times \frac{\text{(total volume in beaker)}}{25.00}$$

Table 2.1

reading number	volume of 0.100 mol dm^{-3} $Ba(OH)_2(aq)$ added to beaker / cm^3	total volume in beaker / cm^3	measured conductivity / $\mu S\,cm^{-1}$	corrected conductivity / $\mu S\,cm^{-1}$
1	0.00	25.00	37 000	37 000
2	5.00		23 000	27 600
3	10.00		12 000	16 800
4	15.00		2 300	3 680
5	20.00		5 000	
6	25.00		12 000	
7	30.00		18 000	
8	35.00		21 000	
9	40.00		24 500	

(i) Complete Table 2.1. [2]

(ii) Identify the independent variable in this experiment.

.... [1]

(c) Plot a graph on the grid in Fig. 2.2 to show the relationship between corrected conductivity and volume of 0.100 mol dm^{-3} $Ba(OH)_2$ added to beaker.

Use a cross (×) to plot each data point.

Draw a line of best fit using readings 1 to 4 and another line of best fit using readings 5 to 9. Extend the lines so that they intersect.

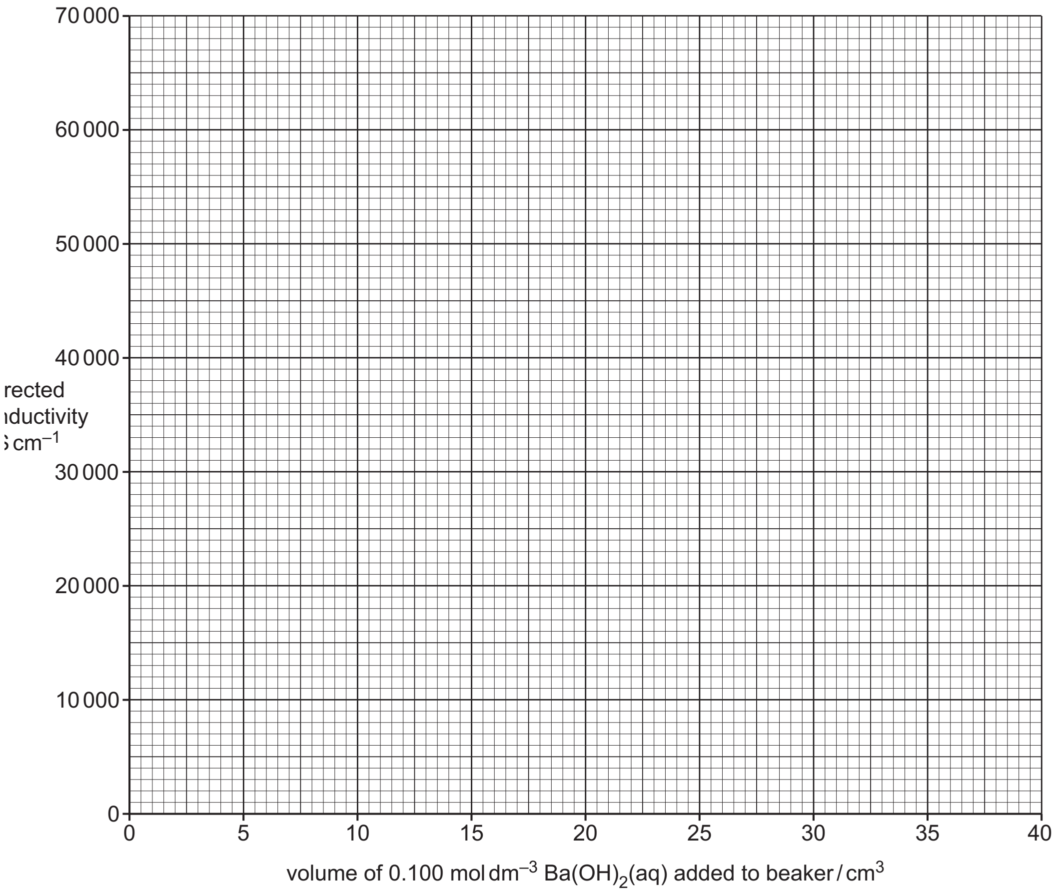

Fig. 2.2

[2]

(d) The point on the graph where the two lines intersect indicates the volume of 0.100 mol dm^{-3} $Ba(OH)_2$(aq) required to react exactly with the SO_4^{2-}(aq) present in 25.00 cm^3 of lake water being tested.

(i) Use the graph in Fig. 2.2 to determine the volume of 0.100 mol dm^{-3} $Ba(OH)_2$(aq) required to react exactly with SO_4^{2-}(aq) in the lake water sample.

volume required = ... cm^3 [1]

(ii) The equation for the reaction taking place in the beaker is shown.

$$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$$

Use your answer in **(d)(i)** to calculate the concentration of SO_4^{2-}(aq) in the lake water sample.

concentration of SO_4^{2-}(aq) = ... mol dm^{-3} [1]

(e) The concentration of $SO_4^{2-}(aq)$ in a sample of water can also be determined by measuring the mass of precipitate produced when excess $Ba(OH)_2(aq)$ is added to the sample.

The student suggests the following method.

step 1 Place 25.0 cm^3 of the water sample in a conical flask.

step 2 Add excess 0.100 $mol\,dm^{-3}$ $Ba(OH)_2(aq)$ to the flask.

step 3 Filter the contents of the flask.

step 4 Dry the residue in a warm oven.

step 5 Measure the mass of residue.

(i) Draw a labelled diagram to describe the arrangement of apparatus that would be needed to complete step 3.

[1]

(ii) Suggest a step that the student should add between steps 3 and 4 to improve this method.

.... [1]

(iii) Describe what the student can do to ensure that the residue weighed in step 5 is completely dry.

....

.... [1]

(iv) The mass of residue is used to calculate the concentration of $SO_4^{2-}(aq)$.

Suggest the effect, if any, on the concentration of $SO_4^{2-}(aq)$ that is calculated if the residue is **not** completely dried in step 4.

Explain your answer.

effect on concentration of $SO_4^{2-}(aq)$ calculated ....

explanation ....

....

[1]

[Total: 13]

Important values, constants and standards

molar gas constant	$R = 8.31\ J\,K^{-1}\,mol^{-1}$
Faraday constant	$F = 9.65 \times 10^4\ C\,mol^{-1}$
Avogadro constant	$L = 6.02 \times 10^{23}\ mol^{-1}$
electronic charge	$e = -1.60 \times 10^{-19}\ C$
molar volume of gas	$V_m = 22.4\ dm^3\,mol^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0\ dm^3\,mol^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14}\ mol^2\,dm^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18\ kJ\,kg^{-1}\,K^{-1}$ ($4.18\ J\,g^{-1}\,K^{-1}$)

The Periodic Table of Elements

Key: atomic number / **atomic symbol** / name / relative atomic mass

Group 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H hydrogen 1.0																	2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0											5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3											13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.2	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

1 Iron is an element that is essential in the human diet. Some people need to take iron supplement tablets to ensure an adequate intake of iron.

You will investigate the mass of iron in an iron supplement tablet by titrating a solution with potassium manganate(VII).

$$Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^-$$

$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$$

FB 1 is an aqueous solution of iron supplement tablets made by dissolving 14 tablets in 1.00 dm^3 of solution. The iron in each tablet is iron(II) sulfate, $FeSO_4 \bullet 7H_2O$.
FB 2 is 0.0100 mol dm^{-3} acidified aqueous potassium manganate(VII), $KMnO_4$.
FB 3 is dilute sulfuric acid, H_2SO_4.

(a) Method

- Fill a burette with **FB 2**.
- Pipette 25.0 cm^3 of **FB 1** into a conical flask.
- Use the 25 cm^3 measuring cylinder to add 10.0 cm^3 of **FB 3** to the conical flask.
- Perform a rough titration and record your burette readings in the space below.

The rough titre is .... cm^3.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make sure any recorded results show the precision of your practical work.
- Record, in a suitable form in the space below, all your burette readings and the volume of **FB 2** added in each accurate titration.

Rinse the burette with distilled water and leave to drain while you continue Question 1.

Results

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results, calculate a suitable mean value to use in your calculations. Show clearly how you obtain the mean value.

25.0 cm^3 of **FB 1** required .... cm^3 of **FB 2**. [1]

(c) Calculations

(i) Give your answers to **(c)(ii)**, **(c)(iii)** and **(c)(iv)** to an appropriate number of significant figures. [1]

(ii) Calculate the amount, in mol, of manganate(VII) ions in the volume of **FB 2** in **(b)**.

amount of MnO_4^- = ... mol [1]

(iii) Use your answer to **(c)(ii)** and the equations at the start of the question to calculate the concentration, in $mol\,dm^{-3}$, of iron(II) ions in **FB 1**.

concentration of Fe^{2+} = ... $mol\,dm^{-3}$ [1]

(iv) Use your answer to **(c)(iii)** to calculate the concentration, in $g\,dm^{-3}$, of iron(II) ions in **FB 1**.

concentration of Fe^{2+} = ... $g\,dm^{-3}$ [1]

(v) The manufacturer of the iron supplement tablets used to make **FB 1** claims that each tablet contains a minimum of 150 mg of Fe^{2+}.

Use your answer to **(c)(iv)** and the information given about **FB 1** to determine whether this claim is correct. Show your working.

[1]

(d) A student used all the **FB 3** and suggests that dilute hydrochloric acid would be a suitable replacement.
Suggest whether the student is correct or not. Explain your answer.

....

....

.... [1]

[Total:14]