

1 What is the oxidation number of Mn in K_2MnO_4 ?

A +4

B +5

C +6

D +7

Your answer

[1]

- 2** 0.0200 mol of calcium oxide is reacted completely with 2.00 mol dm^{-3} HCl.

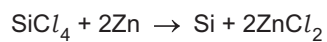
What is the volume, in cm^3 , of 2.00 mol dm^{-3} HCl required for this reaction?

- A** 15
- B** 20
- C** 30
- D** 60

Your answer

[1]

- 3** Silicon can be made by heating silicon tetrachloride, SiCl_4 , with zinc.



8.50 g of SiCl_4 is reacted with an excess of zinc. The percentage yield of silicon is 90%.

What is the mass of silicon made?

- A** 1.26 g
- B** 1.31 g
- C** 1.40 g
- D** 1.55 g

Your answer

[1]

- 4** **HA** and **HB** are two strong monobasic acids.
25.0 cm³ of 6.0 mol dm⁻³ **HA** is mixed with 45.0 cm³ of 3.0 mol dm⁻³ **HB**.

What is the H⁺(aq) concentration, in mol dm⁻³, in the resulting solution?

- A** 1.9
B 2.1
C 4.1
D 4.5

Your answer

[1]

- 5** In the compound $[\text{ICl}_2]^+ [\text{SbCl}_6]^-$, the oxidation number of chlorine is -1 .

What are the oxidation numbers of I and Sb in the compound?

	I	Sb
A	+1	+5
B	+1	+7
C	+3	+5
D	+3	+7

Your answer

[1]

- 6** A student titrates a standard solution of barium hydroxide, $\text{Ba}(\text{OH})_2$, with nitric acid, HNO_3 .
 25.00 cm^3 of $0.0450\text{ mol dm}^{-3}$ $\text{Ba}(\text{OH})_2$ are needed to neutralise 23.35 cm^3 of $\text{HNO}_3(\text{aq})$.

What is the concentration, in mol dm^{-3} , of the nitric acid?

- A** 0.0241
B 0.0482
C 0.0900
D 0.0964

Your answer

[1]

- 7** In the laboratory, acid spills can be cleaned up and made safe by spreading anhydrous sodium carbonate over the spill to neutralise the acid.

A student accidentally spills 50.0 cm^3 of $2.00\text{ mol dm}^{-3}\text{ HCl(aq)}$ on the bench.

What is the minimum mass of anhydrous sodium carbonate required to neutralise the acid?

- A** 4.15 g
B 5.30 g
C 8.30 g
D 10.6 g

Your answer

[1]

8 What is the oxidation number of N in $\text{Mg}(\text{NO}_2)_2 \cdot 3\text{H}_2\text{O}$?

A +2

B +3

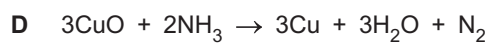
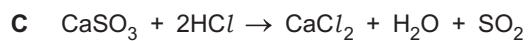
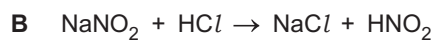
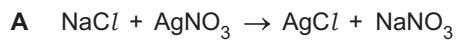
C +4

D +5

Your answer

[1]

9 Which reaction is a redox reaction?



Your answer

[1]

- 10** 3.528 g of a Group 2 metal, **M**, is reacted with an excess of chlorine. The reaction forms 9.775 g of a chloride.

What is metal **M**?

- A** magnesium
- B** calcium
- C** strontium
- D** barium

Your answer

[1]

- 11** Several students titrate 25.00 cm^3 of the same solution of sodium hydroxide, NaOH(aq) with hydrochloric acid, HCl(aq) .

One student obtains a smaller titre than the other students.

Which procedure explains the smaller titre?

- A** The burette readings are taken from the top of the meniscus instead of the bottom of the meniscus.
- B** The conical flask is rinsed with water before carrying out the titration.
- C** An air bubble is released from the jet of the burette during the titration.
- D** The pipette is rinsed with water before filling with NaOH(aq) .

Your answer

[1]

12 Phosphoric acid is a tribasic acid.

What is the mass of $\text{Ca}(\text{OH})_2$ that completely neutralises 100 cm^3 of 0.100 mol dm^{-3} phosphoric acid?

A 0.49 g

B 0.74 g

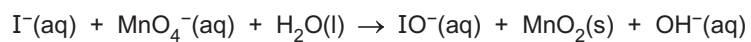
C 1.11 g

D 2.22 g

Your answer

[1]

13 Iodide ions, $\text{I}^{-}(\text{aq})$, react with $\text{MnO}_4^{-}(\text{aq})$. The unbalanced equation is shown below.



What is the ratio of $\text{MnO}_2(\text{s})$ to $\text{OH}^{-}(\text{aq})$ in the balanced equation?

A 1 : 3

B 1 : 2

C 1 : 1

D 3 : 2

Your answer

[1]

14 A chlorate(VII) ion has a 1– charge.

What is the formula for sodium chlorate(VII)?

A NaClO_3

B NaClO_4

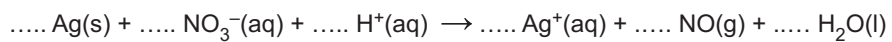
C NaClO_7

D NaClO_8

Your answer

[1]

- 15** The unbalanced equation for the reaction of silver with concentrated nitric acid is shown below.



Which numbers for Ag and H₂O will balance the equation?

	Ag(s)	H ₂ O(l)
A	1	2
B	2	3
C	3	1
D	3	2

Your answer

[1]

16 Chromium(III) oxide, Cr_2O_3 , is reduced to chromium by heating with magnesium.

What is the minimum mass of Mg required to reduce 11.4 g of chromium(III) oxide?

A 0.61 g

B 0.91 g

C 3.65 g

D 5.47 g

Your answer

[1]

17 A student is supplied with 100.0 cm^3 of a solution of 0.400 mol dm^{-3} magnesium iodide, MgI_2 .

A student plans to dilute this solution so that the iodide concentration is 0.250 mol dm^{-3} .

What volume of water, in cm^3 , does the student need to add?

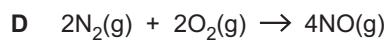
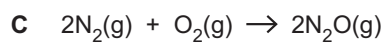
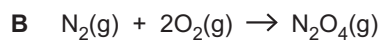
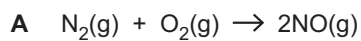
- A** 60.0
- B** 160.0
- C** 220.0
- D** 320.0

Your answer

[1]

18 20 cm³ of nitrogen gas reacts with 10 cm³ of oxygen gas to form 20 cm³ of a gaseous product.

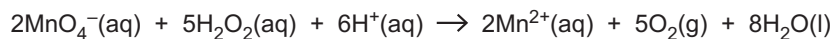
Which equation is the most likely for the reaction?



Your answer

[1]

- 19** Hydrogen peroxide, H_2O_2 , can be oxidised by manganate(VII) ions under acid conditions as shown below.



In a titration, 25.00 cm^3 of a disinfectant containing hydrogen peroxide reacts with 22.00 cm^3 of $0.125\text{ mol dm}^{-3}\text{ KMnO}_4(\text{aq})$.

What is the concentration of H_2O_2 , in mol dm^{-3} , in the disinfectant?
Assume that KMnO_4 only reacts with H_2O_2 in the disinfectant.

- A** 0.0440
B 0.110
C 0.275
D 0.550

Your answer

[1]

20 Prussian blue, $\text{C}_{18}\text{Fe}_7\text{N}_{18}$, is a deep blue pigment containing Fe^{2+} , Fe^{3+} and CN^- ions.

What are the numbers of Fe^{2+} and Fe^{3+} ions in one formula unit of $\text{C}_{18}\text{Fe}_7\text{N}_{18}$?

- A** 2 Fe^{2+} and 5 Fe^{3+}
- B** 3 Fe^{2+} and 4 Fe^{3+}
- C** 4 Fe^{2+} and 3 Fe^{3+}
- D** 5 Fe^{2+} and 2 Fe^{3+}

Your answer

[1]

21 40.0 cm^3 of 0.200 mol dm^{-3} HCl is added to 60.0 cm^3 of 0.100 mol dm^{-3} NaOH .

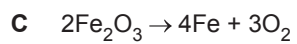
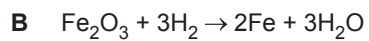
What is the concentration of the resulting solution?

- A** $0.0200\text{ mol dm}^{-3}$ HCl and $0.0200\text{ mol dm}^{-3}$ NaCl
- B** $0.0200\text{ mol dm}^{-3}$ HCl and $0.0400\text{ mol dm}^{-3}$ NaCl
- C** $0.0200\text{ mol dm}^{-3}$ HCl and $0.0600\text{ mol dm}^{-3}$ NaCl
- D** $0.0600\text{ mol dm}^{-3}$ HCl and $0.0200\text{ mol dm}^{-3}$ NaCl

Your answer

[1]

22 Which chemical process is the most sustainable in terms of the atom economy of the iron produced?



Your answer

[1]

23 Which compounds of magnesium can be used as 'antacids'?

A Chlorides

B Hydroxides

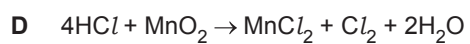
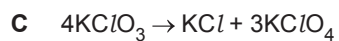
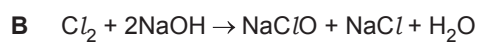
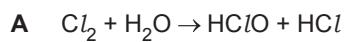
C Nitrates

D Sulfates

Your answer

[1]

24 Which equation does **not** represent a disproportionation reaction?



Your answer

[1]

- 25** 11.895 g of hydrated cobalt(II) chloride, $\text{CoCl}_2 \cdot x\text{H}_2\text{O}$, is heated to remove the water of crystallisation.

After heating to constant mass, the mass of the anhydrous salt was 6.495 g.

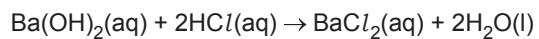
What is the value of x ?

- A** 3
- B** 5
- C** 6
- D** 7

Your answer

[1]

- 26** What volume, in cm^3 , of $0.250 \text{ mol dm}^{-3}$ barium hydroxide solution is required to exactly neutralise 25.0 cm^3 of $0.115 \text{ mol dm}^{-3}$ hydrochloric acid?



- A** 5.75
B 11.50
C 23.00
D 54.35

Your answer

[1]

27 The burette readings from an experiment are shown:

Final reading / cm³	29.35
Initial reading / cm³	2.60

The burette has an uncertainty of $\pm 0.05 \text{ cm}^3$.

What is the percentage uncertainty of the titre?

A 0.17%

B 0.19%

C 0.34%

D 0.37%

Your answer

[1]

28 A mixture of ethanoic acid and ethanol is left to reach equilibrium.

A student determines the amount of ethanoic acid remaining in the equilibrium mixture by titrating the mixture with a solution of sodium hydroxide.

Which row of the table shows a suitable indicator for the titration?

	pH range of the indicator
A	1.2 – 2.8
B	4.8 – 6.0
C	9.4 – 10.6
D	12.0 – 13.4

Your answer

[1]

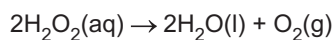
29 This question is about Group 2 and Group 17 (7).

(a) Barium chloride can be prepared from barium hydroxide in a neutralisation reaction.

Write the equation for this reaction. State symbols are **not** required.

..... **[1]**

- 31** Aqueous solutions of hydrogen peroxide, $\text{H}_2\text{O}_2(\text{aq})$, decompose as in the equation below.



A student investigates the decomposition of $\text{H}_2\text{O}_2(\text{aq})$ by measuring the volume of oxygen gas produced over time. All gas volumes are measured at room temperature and pressure.

The student uses 25.0 cm^3 of 2.30 mol dm^{-3} H_2O_2 .

From the results, the student determines the concentration of $\text{H}_2\text{O}_2(\text{aq})$ at each time. The student then plots a concentration–time graph.

- (a)** Determine the total volume of oxygen, measured at room temperature and pressure, that the student should be prepared to collect in this investigation.

Suggest apparatus that would allow this gas volume to be collected, indicating clearly the scale of working.

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.....

..... [3]

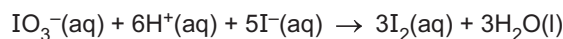
- 32 (a)** Compound **B** is an iodate(V) salt of a Group 1 metal.
The iodate(V) ion has the formula IO_3^- .

A student carries out a titration to find the formula of compound **B**.

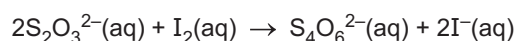
Step 1: The student dissolves 1.55 g of **B** in water and makes up the solution to 250.0 cm^3 in a volumetric flask.

Step 2: The student pipettes 25.00 cm^3 of the solution of **B** into a conical flask, followed by 10 cm^3 of dilute sulfuric acid and an excess of $\text{KI}(\text{aq})$.

The iodate(V) ions are reduced to iodine, as shown below.



Step 3: The resulting mixture is titrated with $0.150\text{ mol dm}^{-3}\text{ Na}_2\text{S}_2\text{O}_3(\text{aq})$.



The student repeats **step 2** and **step 3** until concordant titres are obtained.

Titration readings

Titration	Trial	1	2	3
Final burette reading/ cm^3	24.00	47.40	23.75	47.05
Initial burette reading/ cm^3	0.00	24.00	0.00	23.20
Titre/ cm^3				

Table 20.1

- (i) Complete **Table 20.1** and calculate the mean titre that the student should use for analysing the results.

mean titre = ... cm^3 **[2]**

- (ii) The uncertainty in each burette reading is $\pm 0.05\text{ cm}^3$.

Calculate the percentage uncertainty in the titre obtained from **titration 1**.

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

percentage uncertainty = ... % **[1]**

- (iii) Describe and explain how the student should determine the end point of this titration accurately.

.....
.....
..... [2]

- (iv) Determine the relative formula mass and formula of the Group 1 iodate(V), **B**.

Show your working.

relative formula mass of **B** = ...

formula of **B** = ... [5]

33 (a) Iron(II) gluconate, $\text{C}_{12}\text{H}_{22}\text{FeO}_{14}$, is the active ingredient in some brands of iron supplements.

A student carries out an experiment to determine the mass of iron(II) gluconate in one tablet of an iron supplement, using the method below.

Stage 1 The student crushes two tablets and dissolves the powdered tablets in dilute sulfuric acid.

Stage 2 The student makes up the solution from **Stage 1** to 250.0 cm^3 in a volumetric flask.

Stage 3 The student then titrates 25.0 cm^3 portions of the solution obtained in **Stage 2** with $0.00200\text{ mol dm}^{-3}$ potassium manganate(VII).

The student obtains a mean titre of 13.50 cm^3 .

In this titration, 1 mol of manganate(VII) ions reacts with 5 mol of iron(II) ions.

(i) Explain why the student used $0.00200\text{ mol dm}^{-3}$ potassium manganate(VII) solution for this titration, rather than the more usual concentration of $0.0200\text{ mol dm}^{-3}$ used in manganate(VII) titrations.

.....
 **[1]**

(ii) Use the student's results to determine the mass, in mg, of iron(II) gluconate in **one** tablet.

Give your answer to **3** significant figures.

mass of iron(II) gluconate in one tablet = ... mg **[5]**

- (iii) Some iron supplements contain iron(II) sulfate or iron(II) fumarate.

The information in **Table 18.3** is taken from the labels of two iron supplements, **A** and **B**.

Iron supplement	Iron compound	Mass of iron compound in one tablet/mg
A	iron(II) sulfate, FeSO_4	180
B	iron(II) fumarate, $\text{C}_4\text{H}_2\text{FeO}_4$	210

Table 18.3

Choose which iron supplement, **A** or **B**, would provide the greater mass of iron per tablet.

iron supplement: **[1]**

34 A student adds a total of 45.0 cm^3 of 0.100 mol dm^{-3} NaOH(aq) to 25.0 cm^3 of $0.0800\text{ mol dm}^{-3}$ $\text{C}_2\text{H}_5\text{COOH(aq)}$ and monitors the pH throughout.

(a) Show by calculation that 20.0 cm^3 of NaOH(aq) is required to reach the end point.

[1]

- 35** This question is about reactions and uses of the weak acids methanoic acid, HCOOH , and ethanoic acid, CH_3COOH .

- (a) A student adds magnesium metal to an aqueous solution of ethanoic acid, CH_3COOH . A redox reaction takes place.

Write the overall equation for this reaction and explain, in terms of oxidation numbers, which element has been oxidised and which element has been reduced.

Equation

Oxidation

.....

Reduction

.....

[3]

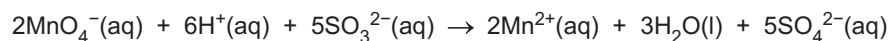
- 36 (a)** Sodium sulfite(IV), Na_2SO_3 , is used as a preservative in some foods.
Food safety legislation allows a maximum of 850 mg Na_2SO_3 per kg of burger meat.

A chemist determines the amount of Na_2SO_3 in a sample of burger meat using a manganate(VII) titration.

Step 1 The Na_2SO_3 from 525 g of burger meat is extracted to form a solution containing $\text{SO}_3^{2-}(\text{aq})$ ions.

Step 2 The solution from **step 1** is made up to 250.0 cm^3 in a volumetric flask with water. 25.0 cm^3 of this diluted solution is pipetted into a conical flask.

Step 3 The pipetted solution from **step 2** is acidified with dilute sulfuric acid and then titrated with $0.0100\text{ mol dm}^{-3}$ potassium manganate(VII), KMnO_4 .



12.60 cm^3 of $\text{KMnO}_4(\text{aq})$ is required to reach the endpoint.

Analyse the results to determine whether the burger meat complies with food safety legislation.

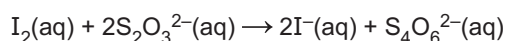
[5]

- 37** A student carries out an experiment to determine the percentage by mass of copper in an ore containing copper in its +2 oxidation state.

The student is provided with a sample of the copper ore, 1 mol dm^{-3} potassium iodide, KI(aq) , and $0.0200 \text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.

The student's method is outlined below.

- Step 1** Add an excess of warm nitric acid to 2.50 g of the ore.
The copper(II) compounds in the ore react, forming aqueous copper(II) nitrate.
- Step 2** Filter the mixture to remove the unreacted rock. Neutralise the filtrate.
- Step 3** Add an excess of aqueous potassium iodide, KI(aq) .
A precipitate of copper(I) iodide and a solution of iodine, $\text{I}_2(\text{aq})$, forms.
- Step 4** Titrate the mixture from **Step 3** using $0.0200 \text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$ in the burette.



26.55 cm^3 of $0.0200 \text{ mol dm}^{-3}$ $\text{Na}_2\text{S}_2\text{O}_3$ are required to reach the end point.

- (a) In **Step 1**, the student observed that bubbles of gas were produced.

Suggest the formula of the copper(II) compound which reacted with HNO_3 to form the gas, and write a full equation for the reaction.

Formula:

Equation: [2]

- (b) Write an **ionic** equation, including state symbols, for the reaction in **Step 3**.

..... [1]

- (c) Suggest a suitable indicator for this titration and state the colour change at the end point in **Step 4**.

Indicator:

Colour from to [1]

- (d) Determine the percentage, by mass, of copper in the copper ore.
Give your answer to an **appropriate** number of significant figures.

percentage = ... % **[4]**

- (e) Explain whether the calculated percentage by mass of copper would be higher, lower or the same if the following changes were made to the method.

- (i) The potassium iodide was not in excess, in **Step 3**.

.....
..... **[1]**

- (ii) The burette readings were read from the top of the meniscus, in **Step 4**.

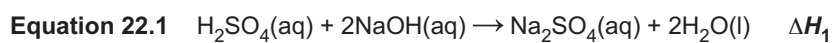
.....
..... **[1]**

- (f) The student then modifies the method in order to obtain a more accurate value for the percentage by mass of copper in the ore. The student decides to use 25.00 g of the copper ore in **Step 1**.

What further modifications should the student make to produce a more accurate value for the percentage by mass of copper in the ore?

.....
.....
.....
.....

38 Sulfuric acid reacts with sodium hydroxide as shown in **Equation 22.1**.



This is a neutralisation reaction.

The student measures out two solutions:

- 25.0 cm^3 of 1.60 mol dm^{-3} $\text{H}_2\text{SO}_4(\text{aq})$
- 55.0 cm^3 of 1.50 mol dm^{-3} $\text{NaOH}(\text{aq})$ (an excess).

(a) Show that NaOH is in excess.

[2]

39 This question is about acids and buffer solutions.

- (a) Succinic acid, $\text{HOOC}(\text{CH}_2)_2\text{COOH}$, is a weak dibasic acid that is used in tablet form in health supplements.

A student plans to determine the mass of succinic acid in one tablet of a succinic acid health supplement.

The student carries out a titration with potassium hydroxide.

The end point occurs when both acidic protons in succinic acid have been replaced as shown in **Equation 19.1**.



The student uses the following method.

- Stage 1** The student crushes four tablets of the health supplement and dissolves the powdered tablets in distilled water.
- Stage 2** The student makes up the solution from **Stage 1** to 250.0 cm^3 in a volumetric flask.
- Stage 3** The student titrates 10.0 cm^3 portions of the solution obtained in **Stage 2** with $0.0600\text{ mol dm}^{-3}$ potassium hydroxide, using phenolphthalein as the indicator.

The student carries out a trial titration, followed by three further titrations. The results are shown below.

Titration	Trial	1	2	3
Final burette reading/ cm^3	25.25	23.75	25.35	25.75
Initial burette reading/ cm^3	2.50	1.30	2.65	3.20
Titre/ cm^3				

- (i) Complete the table and calculate the mean titre that the student should use for analysing the results.

mean titre = ... cm^3 [2]

- (ii) Use the student's results and **Equation 19.1** to calculate the mass, in mg, of succinic acid in **one** tablet of the health supplement.

Give your answer to **3** significant figures.

mass = ... mg **[5]**

- 40** A student adds magnesium to dilute hydrochloric acid in one test tube.
The student adds calcium to dilute hydrochloric acid in a second test tube.

A redox reaction takes place in each test tube.

- (a)** Write half-equations for the reaction of magnesium with hydrochloric acid.

Oxidation half-equation:

Reduction half-equation:

[2]

- 41** A sample of barium oxide is added to distilled water at 25 °C.
A colourless solution forms containing barium hydroxide, Ba(OH)₂.

(a) 10 cm³ of dilute sulfuric acid is added to 10 cm³ of the colourless solution of Ba(OH)₂.

Write an ionic equation, including state symbols, for the reaction.

..... **[1]**

42 (a) Limestone and huntite are two calcium minerals.

(i) A typical sample of limestone contains 95.0% by mass of calcium carbonate, CaCO_3 .

Fertiliser **Z**, $\text{Ca}_5\text{NH}_4(\text{NO}_3)_{11} \cdot 10\text{H}_2\text{O}$ ($M_r = 1080.5 \text{ g mol}^{-1}$) can be made from limestone.

Calculate the mass, in g, of limestone needed to make 1.50 kg of fertiliser **Z**.

Give your answer to **3** significant figures.

mass of limestone = ... g **[3]**

(ii) Huntite is a carbonate mineral with the chemical formula $\text{Mg}_3\text{Ca}(\text{CO}_3)_4$.

Huntite reacts with dilute hydrochloric acid to produce bubbles of a gas and a colourless solution.

Construct the equation for the reaction. Include state symbols.

..... **[2]**

- 43 (a)** A student reacts 1.00 g of strontium carbonate, SrCO_3 , with an excess of dilute nitric acid, HNO_3 . A gas is produced.

(i) Construct the equation for this reaction.

..... **[1]**

- (ii) The student then reacts 1.00 g of calcium carbonate, CaCO_3 , with an excess of dilute nitric acid, HNO_3 .

Explain why the student's two reactions produce different volumes of gas.

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..... **[2]**

- 44** A student reacts an excess of magnesium with 25.0 cm^3 of 0.500 mol dm^{-3} hydrochloric acid, HCl .

The student also reacts an excess of magnesium with 25.0 cm^3 of 0.500 mol dm^{-3} ethanoic acid, CH_3COOH .

- (a)** Construct an ionic equation for the reaction of magnesium with an acid.

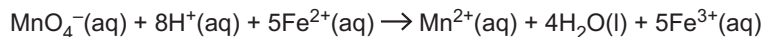
..... **[1]**

45 Some grass fertilisers contain compounds of iron.

During heavy rain, a fertiliser is washed into a nearby river causing the water to be polluted with a mixture of iron(II) and iron(III) ions.

- (a) A student determines the concentration of iron(II) ions in a sample of river water by titration with potassium manganate(VII).

25.0 cm³ portions of river water are acidified with dilute sulfuric acid. Each portion is titrated with 0.00250 mol dm⁻³ potassium manganate(VII) until a colour change is seen.



- (i) State the colour change seen at the end point of the titration.

from to

[1]

- (ii) The student's titration results are shown in the table below.
The trial titre has been omitted.

	1	2	3
Final volume / cm³	12.65	25.60	38.35
Initial volume / cm³	0.00	12.65	25.60
Titre volume / cm³			

Complete the table above and calculate the mean titre that the student should use to determine the concentration of iron(II) ions in the river water.

mean titre = ... cm³ **[2]**

- (iii) Determine the concentration, in mol dm⁻³, of iron(II) ions in the river water.

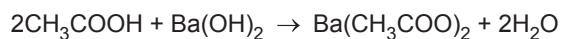
concentration = ... mol dm⁻³ **[3]**

- 46 (a)** An acidified solution containing $\text{Cr}_2\text{O}_7^{2-}$ ions reacts with vanadium(III) ions in a redox reaction to form a solution containing Cr^{3+} ions and VO_2^+ ions.

Construct the overall equation for this reaction.

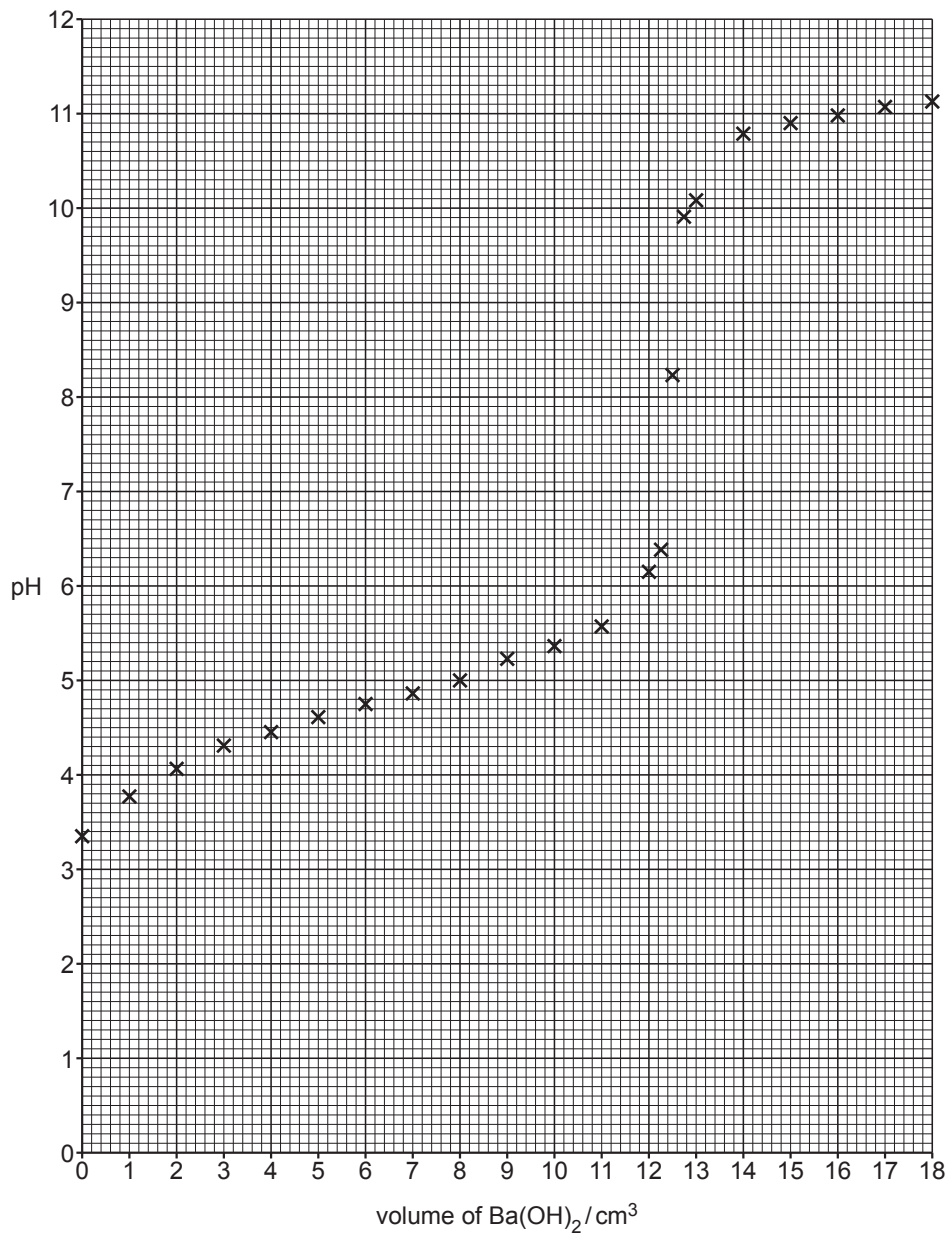
..... [2]

- (a) A student titrates a 10.0 cm^3 sample of ethanoic acid, CH_3COOH , against an aqueous solution of $0.0560\text{ mol dm}^{-3}$ $\text{Ba}(\text{OH})_2$.



The student used a pH meter to measure the pH of the mixture after every addition of $\text{Ba}(\text{OH})_2$ throughout the titration.

The student's results are shown below.



- (i) Draw a best-fit curve on the graph and calculate the concentration of the CH_3COOH solution.

CH_3COOH concentration = ... mol dm^{-3} [5]

- (ii) The end point of the titration can also be found by observing the colour change of an indicator.

The pH ranges of some indicators are shown in the table.

Indicator	pH range
Malachite green	0.2 – 1.8
Bromophenol blue	2.8 – 4.6
Phenol red	6.8 – 8.4
Phenolphthalein	8.2 – 10.0

Identify the indicator in the table that would be suitable to observe the end point of the titration between CH_3COOH and $\text{Ba}(\text{OH})_2$.

..... [1]

- (a) Potassium iodate tablets prevent the uptake of radioactive iodine in the human body following a nuclear accident.

The mass of potassium iodate(V), KIO_3 , in a tablet can be determined by reaction with an aqueous solution of potassium iodide, KI , in the presence of acid.



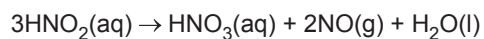
A chemist finds that two KIO_3 tablets react with exactly 26.2 cm^3 0.150 mol dm^{-3} KI .

Calculate the mass, in mg, of KIO_3 in **one** tablet.

Give your answer to the nearest whole number.

mass KIO_3 = ... mg **[4]**

(a) When heated, aqueous HNO_2 disproportionates. The equation is shown below.



- What is meant by **disproportionation**?
- Use oxidation numbers to show that disproportionation has taken place.

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..... **[3]**

- (a) **Mixture A** is a mixture of copper(II) sulfate crystals, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ and iron(II) sulfate crystals, $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$.

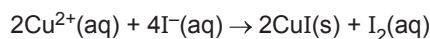
A student carries out a titration to determine the percentage by mass of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ in **Mixture A**.

The student uses the following method.

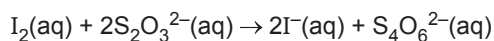
Step 1 Dissolve 9.51 g of **Mixture A** in water and make up the solution to 250.0 cm^3 in a volumetric flask.

Step 2 Pipette 25.0 cm^3 of the solution from **Step 1** into a conical flask and add an excess of aqueous potassium iodide, KI(aq) .

The copper(II) ions react with iodide ions to form a precipitate of copper(I) iodide and a solution of iodine.



Step 3 Titrate the contents of the conical flask from **Step 2** with $0.0800\text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$, using starch as the indicator.



Step 4 Repeat **Step 2** and **Step 3** to obtain concordant titres and calculate the mean titre.

Results

Mean titre = 31.15 cm^3

- (i) Calculate the percentage by mass of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ in **Mixture A**.

Give your answer to 3 significant figures.

Percentage of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ in **Mixture A** = ... % **[5]**

- (ii) The student repeats their method, but after carrying out **Step 1** they leave the solution exposed to the air for a few days.
Some of the iron(II) sulfate is oxidised to iron(III) sulfate.

The student then continues with **Step 2**, **Step 3** and **Step 4** of the method.

This mean titre is greater than 31.15 cm^3 .

Suggest why this mean titre is greater than 31.15 cm^3 .

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..... **[1]**