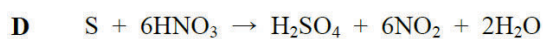
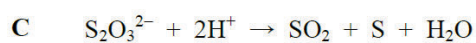
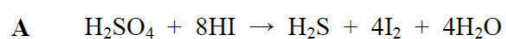


1. Which redox reaction contains the largest change in oxidation state for sulfur?



Your answer

[1]

2. Two tests are carried out on an aqueous solution of copper(II) sulfate, $\text{CuSO}_4(\text{aq})$.

Test 1: Addition of potassium iodide solution

Test 2: Addition of barium chloride solution

Which of the following statements is/are true?

1: Test 1 produces an off-white precipitate and a brown solution.

2: Test 2 produces a white precipitate.

3: Test 1 and Test 2 are both redox reactions.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer

[1]

3. What is the oxidation number of Mn in K_2MnO_4 ?

A +4

B +5

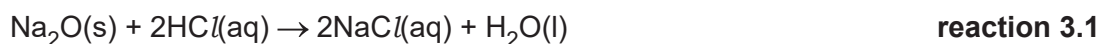
C +6

D +7

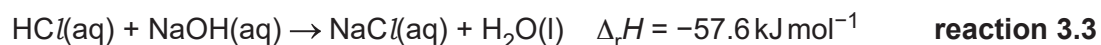
Your answer

[1]

4. A student plans to determine the enthalpy change of **reaction 3.1** shown below.



This enthalpy change can be determined indirectly using Hess' Law from the enthalpy changes of **reaction 3.2** and **reaction 3.3** shown below.



The student will determine the enthalpy change of **reaction 3.2** as outlined below.

- Weigh a bottle containing $\text{Na}_2\text{O}(\text{s})$ and weigh a polystyrene cup.
- Add about 25 cm^3 of water to the polystyrene cup and measure its temperature.
- Add the $\text{Na}_2\text{O}(\text{s})$, stir the mixture, and measure the maximum temperature reached.
- Weigh the empty bottle and weigh the polystyrene cup with the final solution.

Mass readings

Mass of bottle + $\text{Na}_2\text{O}(\text{s})$	= 16.58 g
Mass of empty bottle	= 15.34 g

Mass of empty polystyrene cup	= 21.58 g
Mass of polystyrene cup + final solution	= 47.33 g

Temperature readings

Initial temperature of water	= 20.5°C
Maximum temperature of final solution	= 55.5°C

The density and specific heat capacity, c , of the solution are the same as for water.

- (c) Suggest a modification to this experiment, using the **same** apparatus, which would reduce the percentage errors in the measurements.

Explain your reasoning.

.....

.....

.....

..... [2]

- (d) Sodium oxide, Na_2O , can be prepared by the redox reaction of NaNO_2 and sodium metal. Nitrogen gas is also formed.

- (i) What is the systematic name for NaNO_2 ?

..... [1]

- (ii) Using oxidation numbers, with signs, show the element that is oxidised and the element that is reduced in this reaction.

Element oxidised

Oxidation number change from to

Element reduced

Oxidation number change from to

[2]

- (iii) Construct the equation for this reaction.

Equation [1]

5. In the compound $[ICl_2]^+ [SbCl_6]^-$, 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. 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

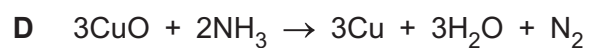
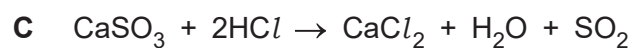
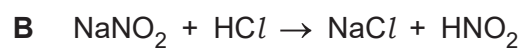
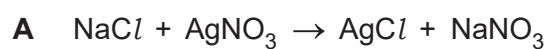
C +4

D +5

Your answer

[1]

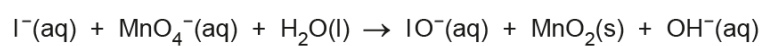
7. Which reaction is a redox reaction?



Your answer

[1]

8. 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]

9. This question is about reactions and uses of the weak acids methanoic acid, HCOOH, and ethanoic acid, CH₃COOH.

- (a) A student adds magnesium metal to an aqueous solution of ethanoic acid, CH₃COOH. 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]

- (b) The K_a values of HCOOH and CH₃COOH are shown in **Table 18.1**.

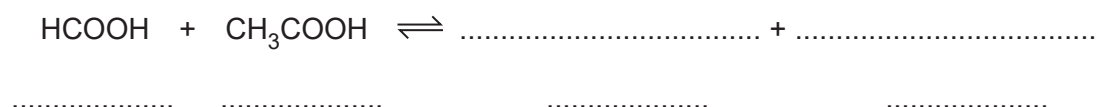
Weak acid	$K_a / \text{mol dm}^{-3}$
HCOOH	1.82×10^{-4}
CH ₃ COOH	1.78×10^{-5}

Table 18.1

A student adds methanoic acid to ethanoic acid.

An equilibrium is set up containing two acid-base pairs.

Complete the equilibrium and label the conjugate acid-base pairs as **A1**, **B1** and **A2**, **B2**.



[2]

(c) Use **Table 18.1** to answer the following questions.

(i) The student measures the pH of $\text{CH}_3\text{COOH}(\text{aq})$ as 2.72.

Show that the concentration of the $\text{CH}_3\text{COOH}(\text{aq})$ is $0.204 \text{ mol dm}^{-3}$.

[2]

(ii) The student plans to make a buffer solution of pH 4.00 from a mixture of $\text{CH}_3\text{COOH}(\text{aq})$ and sodium ethanoate, $\text{CH}_3\text{COONa}(\text{aq})$.

The student mixes 400 cm^3 of $0.204 \text{ mol dm}^{-3}$ $\text{CH}_3\text{COOH}(\text{aq})$ with 600 cm^3 of $\text{CH}_3\text{COONa}(\text{aq})$.

Calculate the concentration of $\text{CH}_3\text{COONa}(\text{aq})$ needed to prepare this buffer solution of pH 4.00.

concentration = mol dm^{-3} [4]

10. A student carries out an investigation to identify two metals, **M** and **X**, by two different methods.

(a) The student is provided with a sample of metal **M**.

The student analyses metal **M** using a 'back-titration' technique:

- The metal is reacted with excess acid.
- The resulting solution is titrated to determine the amount of acid remaining after the reaction.

Stage 1

The student adds 100 cm^3 of $2.10\text{ mol dm}^{-3}\text{ HCl(aq)}$ to 6.90 g of **M**.
An excess of HCl(aq) has been used to ensure that all of metal **M** reacts.

A redox reaction occurs, forming a solution containing **M** in the +2 oxidation state.

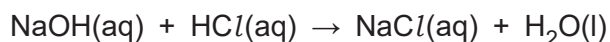
Stage 2

The resulting solution from **Stage 1** is made up to 250.0 cm^3 with distilled water.

Stage 3

A 25.00 cm^3 sample of the diluted solution from **Stage 2** is titrated with $0.320\text{ mol dm}^{-3}\text{ NaOH(aq)}$.

The NaOH(aq) reacts with excess HCl(aq) that remains in **Stage 1**:



The student repeats the titration to obtain concordant titres.

Titration results (The trial titre has been omitted.)

The burette readings have been recorded to the nearest 0.05 cm^3 .

	1	2	3
Final reading / cm^3	27.80	37.55	32.20
Initial reading / cm^3	0.50	10.00	5.00

(i) In **Stage 1**, a redox reaction takes place between **M** and HCl(aq) , forming hydrogen and a solution containing **M** in the +2 oxidation state.

Write an overall equation, with state symbols, for this reaction. Write half-equations for the oxidation and reduction processes.

Overall equation

Oxidation half-equation

Reduction half-equation

[3]

(ii) In **Stage 1**, suggest **two** observations that would confirm that all of metal **M** has reacted.

1

.....

2

.....

[2]

(iii) In **Stage 3**, write the ionic equation for the reaction taking place in the titration.

..... [1]

(iv) Metal **M** can be identified following the steps below.

1. The amount, in mol, of excess $\text{HCl}(\text{aq})$ that remains after the reaction of **M** with $\text{HCl}(\text{aq})$.
2. The amount, in mol, of $\text{HCl}(\text{aq})$ that reacted with **M**.
3. The identity of metal **M**.

Analyse the results to identify metal **M**.

Metal **M** = [6]

(b) The student is provided with the carbonate of an unknown metal, X_2CO_3 .

The student measures the mass loss when the X_2CO_3 is reacted with an **excess** of hydrochloric acid. The equation is shown below.



The reaction is carried out using this method:

Step 1 Add 100 cm³ HCl(aq) to a conical flask and weigh.

Step 2 Add X_2CO_3 to the conical flask and immediately reweigh.

Step 3 After 5 minutes, reweigh the conical flask and contents.

Results

Mass of conical flask + HCl(aq)	172.93 g
Mass of conical flask + X_2CO_3 + HCl(aq) before reaction	187.50 g
Mass of conical flask + contents after 5 minutes	184.75 g

(i) Calculate the amount, in mol, of CO_2 released in the reaction.

Amount of CO_2 = mol [1]

(ii) Calculate the molar mass of X_2CO_3 and identify metal **X**.

Molar mass of X_2CO_3 = g mol⁻¹ Metal **X** = [3]

(c) After analysing the results, the student was told that their molar mass of X_2CO_3 was incorrect.

The student evaluated the experiment for possible reasons for the incorrect result.

(i) The student wondered whether the reaction was complete when the mass was recorded after 5 minutes (**Step 3**).

How could the student modify the experimental procedure to be confident that the reaction was complete?

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

(ii) The student finds out that carbon dioxide is slightly soluble in water.

State and explain how the solubility of CO_2 would affect the calculated molar mass of X_2CO_3 .

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