06 The Mole Concept and Stoichiometry

Set B **Exam practice**

Name	Time 1 hour	Total 35 marks	Score ____ / 35

A Data Booklet may be used. Molar volume of a gas = 22.7 dm^3 mol^{-1} at s.t.p.

Marks by notes section For the marker: total each row. A score below the target means that section of the notes needs revising.

Notes section	Questions	Marks	Target	Score
1 Relative Masses	2	1	1	
3 Empirical and Molecular Formulae	9	3	2	
4 Stoichiometry, Limiting Reagent and Yield	10	5	3	
5 Gas Volumes and Combustion	4(d)	1	1	
6 Volumetric Analysis	6	2	2	
7 Redox Reactions	1, 3, 4(a), 5(a), 7(a), 8(a)	6	4	
8 Redox Titrations	4(b), 4(c), 5(b), 7(b), 8(b), 8(c), 11	17	11	

A Multiple choice

3 MARKS

1 The compound $Bi_2Sr_2Ca_2Cu_3O_{10}$ is a superconductor. In it, the oxidation number of bismuth is +3, of strontium and calcium +2, and of oxygen −2.

What are the possible oxidation numbers of the three copper atoms?

A +1, +1, +2 **B** +1, +2, +3 **C** 0, +1, +3 **D** 0, +2, +3

Answer ☐ [1]

/1

Source: 2025 ACJC J2 Prelim P1 Q8

2 The table shows the absolute abundances of the isotopes in a sample of naturally occurring zinc.

isotope	^{64}Zn	^{65}Zn	^{67}Zn	^{68}Zn
absolute abundance	100	80	20	10

What is the relative atomic mass of this sample of zinc?

A 64.0 **B** 64.9 **C** 68.1 **D** 72.2

Answer ☐ [1]

/1

Source: NJC 2018 Promo, via EJC 2022 Mole Concept Topical Revision, Q2

3 COMMON A disproportionation reaction occurs when an element is oxidised and reduced at the same time. Which equation describes a disproportionation reaction?

A $3ClO^- \rightarrow ClO_3^- + 2Cl^-$

B $2H_2C_2O_4 \rightarrow 2H_2O + 2C + 2CO + 2O_2$

C $2FeSO_4 \rightarrow Fe_2O_3 + SO_2 + SO_3$

D $2KMnO_4 \rightarrow MnO_2 + MnO + K_2O + 2O_2$

Answer [ ] [1]

/1

Source: IJC 2017 Promo, via EJC 2022 Mole Concept Topical Revision, Q18

B Structured questions

32 MARKS

4 FA 1 is a solution of hydrogen peroxide and FA 2 is a standard solution of potassium manganate(VII). A student found that 10 drops of FA 1, when acidified, needed 82 drops of FA 2 for complete reaction. She decided that FA 1 was too concentrated, and needed to be diluted before titration against FA 2.

(a) Construct a balanced equation for the reaction between MnO_4^- ions and H_2O_2 under acidic conditions.

.....

[1]

(b) Explain, with a calculation, why FA 1 would be unsuitable for titration against FA 2 in the burette. Assume 25.0 cm^3 of FA 1 is used.

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.....

[2]

(c) The student diluted v cm^3 of FA 1 to w cm^3 of FA 3. 25.0 cm^3 of FA 3 reacted with exactly y cm^3 of FA 2 of concentration 0.0200 mol dm^{-3}. Show how her results may be used to find the concentration of H_2O_2 in FA 1.

[2]

(d) The volume strength of a hydrogen peroxide solution is the volume of O_2, in dm^3, produced at s.t.p. from 1 dm^3 of the solution, by $2H_2O_2 \rightarrow 2H_2O + O_2$. A commercial solution has a volume strength of 13.4. Calculate its concentration of H_2O_2 in mol dm^{-3}.

[1]

16

Source: 2023 RI J1 Promo Section B Q3(a), (b), (d) and (e)

5 COMMON A 3.20 g impure sample of calcium ethanedioate, CaC_2O_4, is shaken with 100.0 cm^3 of 0.10 mol dm^{-3} acidified MnO_4^-. One of the products is CO_2. The remaining MnO_4^- is reacted with excess iodide to liberate I_2. A 25.0 cm^3 aliquot of the resulting solution needs 24.50 cm^3 of 0.20 mol dm^{-3} $S_2O_3^{2-}$.

$$2MnO_4^- + 10I^- + 16H^+ \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O \quad 2S_2O_3^{2-} + I_2 \rightarrow S_4O_6^{2-} + 2I^-$$

(a) Construct an equation for the reaction between MnO_4^- ions and $C_2O_4^{2-}$ ions.

.....

[1]

(b) Calculate the percentage purity of the sample of CaC_2O_4.

[3]

/4

Source: 2025 ASRJC J2 Prelim P2 Q3(e)

6 The concentration of Al^{3+} in a water sample can be found by titration with $EDTA^{4-}$: $Al^{3+}(aq) + EDTA^{4-}(aq) \rightarrow [Al(EDTA)]^-(aq)$. A 10.0 cm^3 water sample is made up to 250 cm^3 with deionised water. A 25.0 cm^3 aliquot needs 35.45 cm^3 of 0.0200 mol dm^{-3} $EDTA^{4-}$.

(a) Calculate the amount of $EDTA^{4-}$ that reacted with the aluminium ions.

[1]

(b) Calculate the amount of aluminium ions in the water sample.

[1]

/2

Source: 2024 DHS J2 Prelim P2 Q1(a)

7 COMMON N-chlorosuccinimide, $C_4H_4O_2NCl$, is used in water purification tablets. It dissolves in water to give chloric(I) acid, HClO. The amount in a tablet is found by adding excess acidified KI(aq): HClO is reduced to Cl^- by I^-, which is oxidised to I_2. The I_2 is titrated with sodium thiosulfate: $I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$.

(a) Construct a balanced equation for the reaction between HClO and acidified KI(aq).

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[1]

(b) One tablet needed 6.0 cm^3 of 0.0050 mol dm^{-3} sodium thiosulfate. Calculate the mass of N-chlorosuccinimide in the tablet.

[2]

/3

Source: A Level 2011 P3 Q1(c), via EJC 2022 JC1 Mole Concept Tutorial, C8

8 COMMON The percentage of iron in an ore can be found by converting all the iron into $Fe^{2+}(aq)$ and carrying out a redox titration. A sample of iron ore weighing 11.15 g was converted to $Fe^{2+}(aq)$, mixed with dilute sulfuric acid and made up to 250 cm^3. 25.0 cm^3 portions were titrated with 0.100 mol dm^{-3} potassium dichromate(VI). The average titre was 21.45 cm^3.

(a) Write an ionic equation for the reaction of Fe^{2+} ions with acidified $Cr_2O_7^{2-}$ ions.

.....

[1]

(b) Calculate the total amount of Fe^{2+} ions in the solution made up from the iron ore.

[2]

(c) Hence calculate the percentage by mass of iron in the sample of iron ore.

[2]

/5

Source: A Level 2013 P2 Q2(c), modified, via EJC 2022 JC1 Mole Concept Tutorial, C9

9 When P_2S_5 is heated under a vacuum together with caesium sulfide, Cs_2S, and sulfur, it produces an ionic compound R, which has the following composition by mass: Cs, 58.1%; P, 6.78%; S, 35.1%.

(a) COMMON Calculate the empirical formula of compound R and hence deduce its chemical formula, given that its relative formula mass, M_r, is 914.6.

[2]

(b) Compound R contains Cs^+ cations and an anion, present in a 4 : 1 ratio. Write the formula of the anion.

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[1]

/3

Source: 2024 CJC J2 Prelim P2 Q2(e)(i) and (ii)

10 Iron(III) oxide, Fe_2O_3, can be converted into iron metal by reacting it with carbon monoxide. Carbon dioxide is formed as the only by-product in this reaction.

(a) Write a balanced equation for the reaction.

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[1]

0.15 kg of Fe_2O_3 and 60 dm^3 of carbon monoxide at room temperature and pressure were used in the experiment. Calculate

(b) COMMON (i) the maximum mass of iron metal that can be produced,

[2]

(ii) the number of carbon dioxide molecules formed as the by-product,

[1]

(iii) the percentage yield of the experiment, if 70 g of iron metal was actually obtained.

[1]

/5

Source: EJC 2022 JC1 Mole Concept Tutorial, A10

11 CHALLENGE 25.0 cm^3 of a solution containing ethanedioic acid, $H_2C_2O_4$, and sodium ethanedioate, $Na_2C_2O_4$, needed 14.75 cm^3 of 0.100 mol dm^{-3} NaOH for neutralisation. Another 25.0 cm^3 needed 32.00 cm^3 of 0.0205 mol dm^{-3} $KMnO_4$ for oxidation in acid at 60 °C. Calculate the concentrations of ethanedioic acid and of sodium ethanedioate in the solution.

[4]

/4

Source: RJC 2010/11 Moles and Stoichiometry Tutorial, Q15