06 The Mole Concept and Stoichiometry

Set A Foundations

Name | Time 1 hour | Total 38 marks | Score ____ / 38

A Data Booklet may be used. Molar volume of a gas = 24.0 dm^3 mol^{-1} at r.t.p.

A From the lesson

23 MARKS

1 Bromine has two isotopes, ^{79}Br and ^{81}Br. $A_r(Br) = 79.90$. Calculate the percentage abundance of ^{79}Br.

[2]

/2

Source: Learners' Alley, The Mole Concept slides

2 COMMON A hydrocarbon contains 85.7% carbon by mass and has $M_r = 56.0$. Determine its molecular formula.

[2]

/2

Source: Learners' Alley, The Mole Concept slides

3 CHALLENGE 0.600 g of a compound of carbon, hydrogen and oxygen burns completely to give 0.880 g of CO_2 and 0.360 g of H_2O. Determine its empirical formula.

[3]

/3

Source: Learners' Alley, The Mole Concept slides

4 5.00 g of $CaCO_3$ is added to 50.0 cm^3 of 1.00 mol dm^{-3} HCl.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

Identify the limiting reagent, and calculate the volume of CO_2 formed at r.t.p.

[3]

/3

Source: Learners' Alley, The Mole Concept slides

5 COMMON 20 cm^3 of a gaseous hydrocarbon is exploded with 150 cm^3 of oxygen (an excess). After cooling to r.t.p., the volume of gas is 110 cm^3, and 50 cm^3 remains after shaking with excess NaOH(aq). Determine the formula of the hydrocarbon.

[3]

/3

Source: Learners' Alley, The Mole Concept slides

6 COMMON 2.50 g of impure $CaCO_3$ is added to 50.0 cm^3 of 1.00 mol dm^{-3} HCl (an excess). The excess HCl needs 20.0 cm^3 of 0.500 mol dm^{-3} NaOH for neutralisation. Calculate the percentage purity of the $CaCO_3$.

[3]

/3

Source: Learners' Alley, The Mole Concept slides

7 Determine the oxidation number of

(a) Cr in $Cr_2O_7^{2-}$

[1]

(b) S in $S_2O_3^{2-}$

[1]

(c) N in NH_4^+

[1]

/3

Source: Learners' Alley, The Mole Concept slides

8 COMMON Use half-equations to construct a balanced equation for the reaction of $Cr_2O_7^{2-}$ with Fe^{2+} in acid. $Cr_2O_7^{2-}$ is reduced to Cr^{3+}, and Fe^{2+} is oxidised to Fe^{3+}.

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[2]

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Source: Learners' Alley, The Mole Concept slides

9 25.0 cm^3 of 0.100 mol dm^{-3} SO_3^{2-} reacts exactly with 20.0 cm^3 of 0.0500 mol dm^{-3} of an oxidising agent containing one atom of metal M in the +5 oxidation state. The sulfur is oxidised to the +6 state. Determine the final oxidation number of M.

[2]

/2

Source: Learners' Alley, The Mole Concept slides

B Practice

15 MARKS

10 COMMON Which statement is correct?

A One mole of a compound is the amount that contains the same number of atoms as there are in 12.000 g of carbon-12.

B The relative isotopic mass of lithium-7 = (average mass of all the isotopes of lithium) ÷ ($^1/_{12}$ × mass of one atom of carbon-12).

C The relative atomic mass of oxygen = (average mass of one atom of oxygen) ÷ ($^1/_{12}$ × mass of one atom of carbon-12).

D The relative molecular mass of a compound E = (average mass of one atom of E) ÷ ($^1/_{12}$ × mass of one molecule of carbon-12).

Answer [1]

/1

Source: 2024 RVHS J2 Prelim P1 Q2 (also 2019 RI J1 Promo P1 Q1)

11 What volume of distilled water must be added to 50 cm^3 of 0.280 mol dm^{-3} $KMnO_4$ to dilute it to 0.160 mol dm^{-3}?

A 11.5 cm^3 **B** 37.5 cm^3 **C** 38.5 cm^3 **D** 87.5 cm^3

Answer [1]

/1

Source: IJC 2017 Promo, via EJC 2022 Mole Concept Topical Revision, Q10

12 COMMON Lead(IV) oxide, PbO_2, is a strong oxidising agent. Under basic conditions, solid PbO_2 reacts with solid $Cr(OH)_3$ to form CrO_4^{2-} and PbO_2^{2-} ions.

(a) Write the balanced half-equations, and hence construct an overall equation, for the reaction between PbO_2 and $Cr(OH)_3$ under basic conditions.

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A 5.00 g sample containing PbO_2 was reacted with excess $Cr(OH)_3$ in alkaline solution, and the resulting solution of CrO_4^{2-} was made up to 250 cm^3. A 25.0 cm^3 aliquot was acidified, converting the CrO_4^{2-} to $Cr_2O_7^{2-}$, and titrated against 0.150 mol dm^{-3} Fe^{2+}.

$$2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O \quad 6Fe^{2+} + Cr_2O_7^{2-} + 14H^+ \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$$

titration number	1	2	3
final burette reading / cm^3	25.55	33.75	40.90
initial burette reading / cm^3	0.00	8.35	15.60
volume of $Fe^{2+}(aq)$ used / cm^3			

(b) Complete the table. Using the results, calculate the amount of Fe^{2+} that reacted with $Cr_2O_7^{2-}$ in the 25.0 cm^3 aliquot.

[2]

(c) The maximum uncertainty of any single burette reading is ±0.05 cm^3. Calculate the maximum percentage uncertainty in the titre in (b).

[1]

(d) Calculate the percentage by mass of PbO_2 in the sample.

[2]

/7

Source: MJC 2017 Promo, via EJC 2022 Mole Concept Topical Revision, Q4

13 CHALLENGE If the dissolved oxygen concentration (DOC) in a river falls below 5 mg dm^{-3}, most fish cannot survive. In the Winkler method, river water is shaken with excess alkaline Mn^{2+}, which oxygen oxidises to a pale brown precipitate of $Mn(OH)_3$.

(a) The reduction half-equation is $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$. Write the oxidation half-equation, and hence construct the overall ionic equation for the reaction between Mn^{2+} and oxygen under alkaline conditions.

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[2]

The $Mn(OH)_3$ is then reacted with excess KI, and the iodine formed is titrated with sodium thiosulfate.

$$2KI + 2Mn(OH)_3 \rightarrow I_2 + 2Mn(OH)_2 + 2KOH \quad 2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$$

(b) 25.0 cm^3 of river water treated in this way required 25.00 cm^3 of 0.00100 mol dm^{-3} $Na_2S_2O_3$.

(i) Fill in the blanks with whole numbers: ___O_2 ≡ ___$Mn(OH)_3$ ≡ ___I_2 ≡ ___$Na_2S_2O_3$ **[1]**

(ii) Calculate the amount of dissolved oxygen in 25.0 cm^3 of river water. **[1]**

(iii) Calculate the DOC in mg dm^{-3}, and hence decide whether fish can survive in the river.

[2]

16

Source: CJC 2018 Promo, via EJC 2022 Mole Concept Topical Revision, Q5