IB Chemistry SL

Topic1 Questions and Answers

1. What amount of oxygen, O_2, (in moles) contains 1.8×10^{22} molecules?

A. 0.0030

B. 0.030

C. 0.30

D. 3.0

(Total 1 mark)

2. Which compound has the empirical formula with the greatest mass?

A. C_2H_6

B. C_4H_{10}

C. C_5H_{10}

D. C_6H_6

(Total 1 mark)

3. $\_\_C_2H_2(g) + \_\_O_2(g) \rightarrow \_\_ CO_2(g) + \_\_ H_2O(g)$

When the equation above is balanced, what is the coefficient for oxygen?

A. 2

B. 3

C. 4

D. 5

(Total 1 mark)

4. 3.0 dm^3 of sulfur dioxide is reacted with 2.0 dm^3 of oxygen according to the equation below.

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

What volume of sulfur trioxide (in dm^3) is formed? (Assume the reaction goes to completion and all gases are measured at the same temperature and pressure.)

A. 5.0

B. 4.0

C. 3.0

D. 2.0

(Total 1 mark)

5. What will happen to the volume of a fixed mass of gas when its pressure and temperature (in Kelvin) are both doubled?

A. It will not change.

B. It will increase.

C. It will decrease.

D. The change cannot be predicted.

(Total 1 mark)

6. What amount (in moles) is present in 2.0 g of sodium hydroxide, NaOH?

A. 0.050

B. 0.10

C. 20

D. 80

(Total 1 mark)

7. A hydrocarbon contains 90% by mass of carbon. What is its empirical formula?

A. CH_2

B. C_3H_4

C. C_7H_{10}

D. C_9H_{10}

(Total 1 mark)

8. Copper can react with nitric acid as follows.

$$3Cu + \_HNO_3 \rightarrow \_Cu(NO_3)_2 + \_H_2O + \_NO$$

What is the coefficient for HNO_3 when the equation is balanced?

A. 4

B. 6

C. 8

D. 10

(Total 1 mark)

9. Lithium hydroxide reacts with carbon dioxide as follows.

$$2LiOH + CO_2 \rightarrow Li_2 CO_3 + H_2O$$

What mass (in grams) of lithium hydroxide is needed to react with 11 g of carbon dioxide?

A. 6

B. 12

C. 24

D. 48

(Total 1 mark)

10. Which change in conditions would increase the volume of a fixed mass of gas?

	Pressure /kPa	Temperature /K
A.	Doubled	Doubled
B.	Halved	Halved
C.	Doubled	Halved
D.	Halved	Doubled

(Total 1 mark)

11. How many hydrogen atoms are contained in one mole of ethanol, C_2H_5OH?

A. 5

B. 6

C. 1.0×10^{23}

D. 3.6×10^{24}

(Total 1 mark)

12. The percentage by mass of the elements in a compound is

C = 72%, H = 12%, O = 16%.

What is the mole ratio of C:H in the empirical formula of this compound?

A. 1 : 1

B. 1 : 2

C. 1 : 6

D. 6 : 1

(Total 1 mark)

13. What is the coefficient for $O_2(g)$ when the equation below is balanced?

$$\_\_C_3H_8(g) + \_\_O_2(g) \rightarrow \_\_CO_2(g) + \_\_H_2O(g)$$

A. 2

B. 3

C. 5

D. 7

(Total 1 mark)

14. What amount of NaCl (in moles) is required to prepare 250 cm^3 of a 0.200 mol dm^{-3} solution?

A. 50.0

B. 1.25

C. 0.800

D. 0.0500

(Total 1 mark)

15. For which set of conditions does a fixed mass of an ideal gas have the greatest volume?

	Temperature	**Pressure**
A.	low	low
B.	low	high
C.	high	high
D.	high	low

(Total 1 mark)

16. Which of the following contains the greatest number of molecules?

A. 1 g of CH_3Cl

B. 1 g of CH_2Cl_2

C. 1 g of $CHCl_3$

D. 1 g of CCl_4

(Total 1 mark)

17. Which of the following compounds has/have the empirical formula CH_2O?

I. CH_3COOH

II. $C_6H_{12}O_6$

III. $C_{12}H_{22}O_{11}$

A. II only

B. III only

C. I and II only

D. II and III only

(Total 1 mark)

18. Assuming complete reaction, what volume of 0.200 mol dm^{-3} HCl(aq) is required to neutralize 25.0 cm^3 of 0.200 mol dm^{-3} $Ba(OH)_2$(aq)?

A. 12.5 cm^3

B. 25.0 cm^3

C. 50.0 cm^3

D. 75.0 cm^3

(Total 1 mark)

19. Under what conditions would one mole of methane gas, CH_4, occupy the smallest volume?

A. 273 K and 1.01×10^5 Pa

B. 273 K and 2.02×10^5 Pa

C. 546 K and 1.01×10^5 Pa

D. 546 K and 2.02×10^5 Pa

(Total 1 mark)

20. The temperature in Kelvin of 2.0 dm^3 of an ideal gas is doubled and its pressure is increased by a factor of four. What is the final volume of the gas?

A. 1.0 dm^3

B. 2.0 dm^3

C. 3.0 dm^3

D. 4.0 dm^3

(Total 1 mark)

21. Which is a correct definition of the term *empirical formula*?

A. formula showing the numbers of atoms present in a compound

B. formula showing the numbers of elements present in a compound

C. formula showing the actual numbers of atoms of each element in a compound

D. formula showing the simplest ratio of numbers of atoms of each element in a compound

(Total 1 mark)

22. The reaction of ethanal and oxygen can be represented by the unbalanced equation below.

$$\_\_\ CH_3CHO + \_\_\ O_2 \rightarrow \_\_\ CO_2 + \_\_\ H_2O$$

When the equation is balanced using the smallest possible integers, what is the coefficient for O_2?

A. 3

B. 4

C. 5

D. 6

(Total 1 mark)

23. The equation for the complete combustion of butane is

$$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$$

What is the amount (in mol) of carbon dioxide formed by the complete combustion of three moles of butane?

A. 4

B. 8

C. 12

D. 24

(Total 1 mark)

24. Which solution contains the greatest amount (in mol) of solute?

A. 10.0 cm^3 of 0.500 mol dm^{-3} NaCl

B. 20.0 cm^3 of 0.400 mol dm^{-3} NaCl

C. 30.0 cm^3 of 0.300 mol dm^{-3} NaCl

D. 40.0 cm^3 of 0.200 mol dm^{-3} NaCl

(Total 1 mark)

25. A fixed mass of an ideal gas has a volume of 800 cm^3 under certain conditions. The pressure (in kPa) and temperature (in K) are both doubled. What is the volume of the gas after these changes with other conditions remaining the same?

A. 200 cm^3

B. 800 cm^3

C. 1600 cm^3

D. 3200 cm^3

(Total 1 mark)

26. The complete oxidation of propane produces carbon dioxide and water as shown below.

$$C_3H_8 + \_\_O_2 \rightarrow \_\_CO_2 + \_\_H_2O$$

What is the total of the coefficients for the **products** in the balanced equation for 1 mole of propane?

A. 6

B. 7

C. 12

D. 13

(Total 1 mark)

27. The relative molecular mass (M_r) of a compound is 60. Which formulas are possible for this compound?

I. $CH_3CH_2CH_2NH_2$

II. $CH_3CH_2CH_2OH$

III. $CH_3CH(OH)CH_3$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

(Total 1 mark)

28. Which sample has the least number of atoms?

A. 1 mol of H_2SO_4

B. 1 mol of CH_3COOH

C. 2 mol of H_2O_2

D. 2 mol of NH_3

(Total 1 mark)

29. Avogadro's constant has the same value as the number of

A. molecules in 1 mol of solid iodine.

B. atoms in 1 mol of chlorine gas.

C. ions in 1 mol of solid potassium bromide.

D. protons in 1 mol of helium gas.

(Total 1 mark)

30. What is the total of **all** the coefficients in the balanced equation for the reduction of 1 mol of MnO_4^-?

$$\_\_ MnO_4^- + \_\_H^+ + \_\_ e^- \rightarrow \_\_Mn^{2+} + \_\_H_2O$$

A. 5

B. 9

C. 17

D. 19

(Total 1 mark)

31. Which contains the same number of ions as the value of Avogadro's constant?

A. 0.5 mol NaCl

B. 0.5 mol $MgCl_2$

C. 1.0 mol Na_2O

D. 1.0 mol MgO

(Total 1 mark)

32. A reaction occurring in the extraction of lead from its ore can be represented by this unbalanced equation:

$$\_\_ PbS + \_\_O_2 \rightarrow \_\_ PbO + \_\_ SO_2$$

When the equation is balanced using the smallest possible whole numbers, what is the coefficient for O_2?

A. 1

B. 2

C. 3

D. 4

(Total 1 mark)

33. The equation for a reaction occurring in the synthesis of methanol is

$$CO_2 + 3H_2 \rightarrow CH_3OH + H_2O$$

What is the maximum amount of methanol that can be formed from 2 mol of carbon dioxide and 3 mol of hydrogen?

A. 1 mol

B. 2 mol

C. 3 mol

D. 5 mol

(Total 1 mark)

34. Which solution contains 0.1 mol of sodium hydroxide?

A. 1 cm^3 of 0.1 mol dm^{-3} NaOH

B. 10 cm^3 of 0.1 mol dm^{-3} NaOH

C. 100 cm^3 of 1.0 mol dm^{-3} NaOH

D. 1000 cm^3 of 1.0 mol dm^{-3} NaOH

(Total 1 mark)

35. A cylinder of gas is at a pressure of 40 kPa. The volume and temperature (in K) are both doubled. What is the pressure of the gas after these changes?

A. 10 kPa

B. 20 kPa

C. 40 kPa

D. 80 kPa

(Total 1 mark)

36. Which of the following quantities has units?

A. Relative atomic mass

B. Relative molecular mass

C. Molar mass

D. Mass number

(Total 1 mark)

37. The empirical formula of a compound is C_2H_4O. Which molecular formulas are possible for this compound?

I. CH_3COOH

II. $CH_3CH_2CH_2COOH$

III. $CH_3COOCH_2CH_3$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

(Total 1 mark)

38. Calcium carbonate decomposes on heating as shown below.

$$CaCO_3 \rightarrow CaO + CO_2$$

When 50 g of calcium carbonate are decomposed, 7 g of calcium oxide are formed. What is the percentage yield of calcium oxide?

A. 7%

B. 25%

C. 50%

D. 75%

(Total 1 mark)

39. Sodium reacts with water as shown below.

$$\_\_\ Na + \_\_\ H_2O \rightarrow \_\_\ NaOH + \_\_\ H_2$$

What is the total of **all** the coefficients when the equation is balanced using the smallest possible whole numbers?

A. 3

B. 4

C. 6

D. 7

(Total 1 mark)

40. What is the total number of ions present in the formula, $Al_2(SO_4)_3$?

A. 2

B. 3

C. 5

D. 6

(Total 1 mark)

41. A 4 g sample of sodium hydroxide, NaOH, is dissolved in water and made up to 500 cm^3 of aqueous solution. What is the concentration of the resulting solution?

A. 0.1 mol dm^{-3}

B. 0.2 mol dm^{-3}

C. 0.5 mol dm^{-3}

D. 1.0 mol dm^{-3}

(Total 1 mark)

42. Methane, CH_4, burns in oxygen gas to form carbon dioxide and water. How many moles of carbon dioxide will be formed from 8.0 g of methane?

A. 0.25

B. 0.50

C. 1.0

D. 2.0

(Total 1 mark)

43. What is the empirical formula of a compound containing 50% by mass of element X (A_r = 20) and 50% by mass of element Y (A_r = 25)?

A. XY

B. X_3Y_2

C. X_4Y_5

D. X_5Y_4

(Total 1 mark)

44. Assuming complete reaction, what volume of 0.200 mol dm^{-3} potassium hydroxide solution (KOH(aq)), is required to neutralize 25.0 cm^3 of 0.200 mol dm^{-3} aqueous sulfuric acid, (H_2SO_4(aq))?

A. 12.5 cm^3

B. 25.0 cm^3

C. 50.0 cm^3

D. 75.0 cm^3

(Total 1 mark)

45. Consider the following reaction.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

If the reaction is made to go to completion, what volume of ammonia (in dm^3) can be prepared from 25 dm^3 of nitrogen and 60 dm^3 of hydrogen? All volumes are measured at the same temperature and pressure.

A. 40

B. 50

C. 85

D. 120

(Total 1 mark)

46. The temperature in Kelvin of 1.0 dm^3 of an ideal gas is doubled and its pressure is tripled. What is the final volume of the gas in dm^3?

A. $\frac{1}{3}$

B. $\frac{2}{3}$

C. $\frac{3}{2}$

D. $\frac{1}{6}$

(Total 1 mark)

47. On complete combustion, a sample of a hydrocarbon compound produces 1.5 mol of carbon dioxide and 2.0 mol of water. What is the molecular formula of this hydrocarbon?

A. C_2H_2

B. C_2H_4

C. C_3H_4

D. C_3H_8

(Total 1 mark)

48. When excess $BaCl_2(aq)$ was added to a sample of $Fe(NH_4)_2(SO_4)_2(aq)$ to determine the amount in moles of sulfate present, 5.02×10^{-3} mol of $BaSO_4$ was obtained. How many moles of sulfate ions and iron ions were in the sample of $Fe(NH_4)_2(SO_4)_2$?

	Amount of sulfate ions / moles	Amount of iron ions / moles
A.	5.02×10^{-3}	2.51×10^{-3}
B.	10.04×10^{-3}	5.02×10^{-3}
C.	2.51×10^{-3}	5.02×10^{-3}
D.	10.04×10^{-3}	2.51×10^{-3}

(Total 1 mark)

49. What volume of 0.500 mol dm^{-3} sulfuric acid solution is required to react completely with 10.0 g of calcium carbonate according to the equation below?

$$CaCO_3(s) + H_2SO_4(aq) \rightarrow CaSO_4(aq) + H_2O(l) + CO_2(g)$$

A. 100 cm^3

B. 200 cm^3

C. 300 cm^3

D. 400 cm^3

(Total 1 mark)

50. Which expression gives the amount (in mol) of a substance, if the mass is given in grams?

A. $\frac{\text{mass}}{\text{molar mass}}$

B. $\frac{\text{molar mass}}{\text{mass}}$

C. $\frac{1}{\text{molar mass}}$

D. mass × molar mass

(Total 1 mark)

51. What is the total number of atoms in 0.20 mol of propanone, CH_3COCH_3?

A. 1.2×10^{22}

B. 6.0×10^{23}

C. 1.2×10^{24}

D. 6.0×10^{24}

(Total 1 mark)

52. When the equation below is balanced for 1 mol of C_3H_4, what is the coefficient for O_2?

$$C_3C_4 + \_O_2 \rightarrow \_CO_2 + \_H_2O$$

A. 2

B. 3

C. 4

D. 5

(Total 1 mark)

53. Ethyne, C_2H_2, reacts with oxygen according to the equation below. What volume of oxygen (in dm^3) reacts with 0.40 dm^3 of C_2H_2?

$$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(g)$$

A. 0.40

B. 0.80

C. 1.0

D. 2.0

(Total 1 mark)

54. Ethyne, C_2H_2, reacts with oxygen according to the equation below. What volume of oxygen (in dm^3) reacts with 0.40 dm^3 of C_2H_2?

$$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(g)$$

A. 0.40

B. 0.80

C. 1.0

D. 2.0

(Total 1 mark)

55. What is the coefficient for H^+ when the redox equation below is balanced?

$$\_\_Ag(s) + \_\_NO_3^-(aq) + \_\_H^+(aq) \rightarrow \_\_Ag^+(aq) + \_\_NO(g) + \_\_H_2O(l)$$

A. 1

B. 2

C. 3

D. 4

(Total 1 mark)

56. How many hydrogen atoms are in one mole of ethanol, C_2H_5OH?

A. 1.00×10^{23}

B. 3.61×10^{24}

C. 5.00

D. 6.00

(Total 1 mark)

57. What is the coefficient for $H_2SO_4(aq)$ when the following equation is balanced, using the smallest possible integers?

$$\_\_Mg_3N_2(s) + \_\_H_2SO_4(aq) \rightarrow \_\_MgSO_4(aq) + \_\_(NH_4)_2SO_4(aq)$$

A. 1

B. 3

C. 4

D. 7

(Total 1 mark)

58. Air bags in cars inflate when sodium azide decomposes to form sodium and nitrogen:

$$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$$

Calculate the amount, in moles, of nitrogen gas produced by the decomposition of 2.52 mol of $NaN_3(s)$.

A. 1.68

B. 2.52

C. 3.78

D. 7.56

(Total 1 mark)

59. **What volume, in cm^3, of 0.200 mol dm^{-3} HCl(aq) is required to neutralize 25.0 cm^3 of 0.200 mol dm^{-3} $Ba(OH)_2(aq)$?**

A. 12.5

B. 25.0

C. 50.0

D. 75.0

(Total 1 mark)

60. The relative molecular mass of aluminium chloride is 267 and its composition by mass is 20.3% Al and 79.7% chlorine. Determine the empirical and molecular formulas of aluminium chloride.

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(Total 4 marks)

61. Sodium reacts with water as follows.

$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$$

1.15 g of sodium is allowed to react completely with water. The resulting solution is diluted to 250 cm^3. Calculate the concentration, in mol dm^{-3}, of the resulting sodium hydroxide solution.

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(Total 3 marks)

62. (i) Calcium carbonate is added to separate solutions of hydrochloric acid and ethanoic acid of the same concentration. State **one** similarity and **one** difference in the observations you could make.

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(2)

(ii) Write an equation for the reaction between hydrochloric acid and calcium carbonate.

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(iii) Determine the volume of 1.50 mol dm^{-3} hydrochloric acid that would react with exactly 1.25 g of calcium carbonate.

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(3)

(iv) Calculate the volume of carbon dioxide, measured at 273 K and 1.01×10^5 Pa, which would be produced when 1.25 g of calcium carbonate reacts completely with the hydrochloric acid.

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(2)

(Total 9 marks)

63. An organic compound, **A**, containing only the elements carbon, hydrogen and oxygen was analysed.

(a) **A** was found to contain 54.5% C and 9.1% H by mass, the remainder being oxygen. Determine the empirical formula of the compound.

(3)

(b) A 0.230 g sample of **A**, when vaporized, had a volume of 0.0785 dm^3 at 95°C and 102 kPa. Determine the relative molecular mass of **A**.

(3)

(c) Determine the molecular formula of **A** using your answers from parts (a) and (b).

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(1)
(Total 7 marks)

64. An organic compound **A** contains 62.0% by mass of carbon, 24.1% by mass of nitrogen, the remainder being hydrogen.

(i) Determine the percentage by mass of hydrogen and the empirical formula of **A**.

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(3)

(ii) Define the term relative molecular mass.

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(iii) The relative molecular mass of **A** is 116. Determine the molecular formula of **A**.

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(1)
(Total 6 marks)

65. An organic compound A contains 62.0% by mass of carbon, 24.1% by mass of nitrogen, the remainder being hydrogen.

(i) Determine the percentage by mass of hydrogen and the empirical formula of **A**.

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(3)

(ii) Define the term *relative molecular mass*.

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(2)

(iii) The relative molecular mass of **A** is 116. Determine the molecular formula of **A**.

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(1)
(Total 6 marks)

66. Propane and oxygen react according to the following equation.

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$$

Calculate the volume of carbon dioxide and water vapour produced and the volume of oxygen remaining, when 20.0 dm^3 of propane reacts with 120.0 dm^3 of oxygen. All gas volumes are measured at the same temperature and pressure.

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(Total 3 marks)

67. State and explain what would happen to the pressure of a given mass of gas when its absolute temperature and volume are both doubled.

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(Total 3 marks)

68. (i) Crocetin consists of the elements carbon, hydrogen and oxygen. Determine the empirical formula of crocetin, if 1.00 g of crocetin forms 2.68 g of carbon dioxide and 0.657 g of water when it undergoes complete combustion.

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(ii) Determine the molecular formula of crocetin given that 0.300 mole of crocetin has a mass of 98.5 g

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(2)
(Total 8 marks)

69. A solution containing ammonia requires 25.0 cm^3 of 0.100 mol dm^{-3} hydrochloric acid to reach the equivalence point of a titration.

(i) Write an equation for the reaction of ammonia with hydrochloric acid

(1)

(ii) Calculate the amount (in mol) of hydrochloric acid and ammonia that react.

(2)

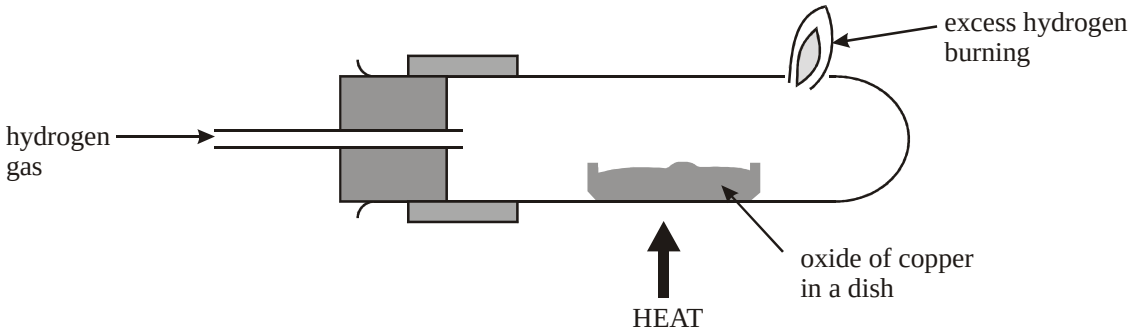
(iii) Calculate the mass of ammonia in the solution.

(2)
(Total 5 marks)

70. A toxic gas, A, consists of 53.8% nitrogen and 46.2% carbon by mass. At 273 K and 1.01×10^5 Pa, 1.048 g of A occupies 462 cm^3. Determine the empirical formula of A. Calculate the molar mass of the compound and determine its molecular structure.

(Total 3 marks)

71. An oxide of copper was reduced in a stream of hydrogen as shown below.



After heating, the stream of hydrogen gas was maintained until the apparatus had cooled.

The following results were obtained.

Mass of empty dish = 13.80 g
Mass of dish and contents before heating = 21.75 g
Mass of dish and contents after heating and leaving to cool = 20.15 g

(a) Explain why the stream of hydrogen gas was maintained until the apparatus cooled.

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(1)

(b) Calculate the empirical formula of the oxide of copper using the data above, assuming

complete reduction of the oxide.

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(3)

(c) Write an equation for the reaction that occurred.

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(1)

(d) State **two** changes that would be observed inside the tube as it was heated.

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(2)

(Total 7 marks)

72. Copper metal may be produced by the reaction of copper(I) oxide and copper(I) sulfide according to the below equation.

$$2Cu_2O + Cu_2S \rightarrow 6Cu + SO_2$$

A mixture of 10.0 kg of copper(I) oxide and 5.00 kg of copper(I) sulfide was heated until no further reaction occurred.

(a) Determine the limiting reagent in this reaction, showing your working.

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(3)

(b) Calculate the maximum mass of copper that could be obtained from these masses of reactants.

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(2)

(Total 5 marks)

73. The reaction below represents the reduction of iron ore to produce iron.

$$2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$$

A mixture of 30 kg of Fe_2O_3 and 5.0 kg of C was heated until no further reaction occurred. Calculate the maximum mass of iron that can be obtained from these masses of reactants.

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(Total 5 marks)

74. 0.502 g of an alkali metal sulfate is dissolved in water and excess barium chloride solution, $BaCl_2(aq)$ is added to precipitate all the sulfate ions as barium sulfate, $BaSO_4(s)$. The precipitate is filtered and dried and weighs 0.672 g.

(a) Calculate the amount (in mol) of barium sulfate formed.

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(2)

(b) Determine the amount (in mol) of the alkali metal sulfate present.

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(1)

(c) Determine the molar mass of the alkali metal sulfate and state its units.

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(2)

(d) Deduce the identity of the alkali metal, showing your workings.

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(e) Write an equation for the precipitation reaction, including state symbols.

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(2)

(Total 9 marks)

75. 0.600 mol of aluminium hydroxide is mixed with 0.600 mol of sulfuric acid, and the following reaction occurs:

$$2Al(OH)_3(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 6H_2O(l)$$

(a) Determine the limiting reactant.

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(b) Calculate the mass of $Al_2(SO_4)_3$ produced.

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(2)

(c) Determine the amount (in mol) of excess reactant that remains.

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(1)

(d) Define a *Brønsted-Lowry* acid and a *Lewis base.*

Brønsted-Lowry acid

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Lewis base

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(2)

(e) $H_2SO_4(aq)$ is a strong acid. State the name and the formula of any weak acid.

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(1)

(Total 8 marks)

1. B

2. B

3. D

4. C

5. A

6. A

7. B

8. C

9. B

10. D

11. D

12. B

13. C

14. D

15. D

16. A

17. C

18. C

19. B

20. A

21. D

22. C

23. C

24. C

25. B

26. B

27. C

28. A

29. A

30. D

31. A

32. C

33. A

34. C

35. C

36. C

37. C

38. B

39. D

40. C

41. B

42. B

43. D

44. C

45. A

46. B

47. D

48. A

49. B

50. A

51. C

52. C

53. C

54. C

55. D

56. B

57. C

58. C

59. C

60. Al $\frac{20.3}{26.98}$ Cl $\frac{79.70}{35.45}$ or similar working *(no penalty for use of 27 or 35.5)*;

empirical formula $AlCl_3$;

molecular formula: n = $\frac{267}{133.5}$ = 2;

Al_2Cl_6;

*Full credit can be obtained if the calculations are carried out by another valid method. Two correct formulas but no valid method scores **[2 max]**.*

[4]

61. moles of Na = $\frac{1.15}{23}$ = 0.05;

moles of NaOH = 0.05;

Accept "same as moles of Na"

concentration = $\left(\frac{0.05}{0.25}\right)$ = 0.20 (mol dm^{-3}) 3

Allow ECF from moles of NaOH

[3]

62. (i) bubbling/effervescence/dissolving of $CaCO_3$/gas given off (*do not accept* CO_2 *produced*);
more vigorous reaction with HCl/*OWTTE*; 2

(ii) $2HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(1)$; 2
***[1]** for correct formulas, **[1]** for balanced, state symbols not*

(iii) amount of $CaCO_3$ = $\frac{1.25}{100.09}$ (*no penalty for use of 100*);
amount of HCl = 2×0.0125 = 0.0250 mol (*allow ECF*);
volume of HCl = 0.0167 dm^3/16.7 cm^3 (*allow ECF*); 3

(iv) 1:1 ratio of $CaCO_3$ to CO_2 /use 0.0125 moles CO_2 (*allow ECF*);
(0.0125×22.4) = 0.28 dm^3/280 cm^3/2.8×10^{-4} m^3 (*allow ECF*); 1
Accept calculation using pV=nRT.

[9]

63. (a) % of oxygen = 36.4;

$C = \frac{54.5}{12.01}, H = \frac{9.1}{1.01}, O = \frac{36.4}{16.00}$;

Do not penalize if 12, 1 and 16 are used.

C_2H_4O; 3

If atomic numbers or incorrect A_r values used, only first mark can be scored.

*Award **[3]** for correct formula without working.*

(b) $pV = nRT / pV = \frac{mRT}{M_r}$ /correct rearrangement;

$M_r = \frac{0.230 \times 8.31 \times 368}{102 \times 10^3 \times 0.0785 \times 10^{-3}}$;

*Award **[1]** for 368 even if incorrect expression given.*

$M_r = 87.8$; 3

Accept answer in range 87.8 to 88.

Do not allow ECF.

*Award **[3]** for correct final answer*

(c) $C_4H_8O_2$; 1

Answer does not need to show working to receive the mark.

Do not allow ECF.

[7]

64. (i)

C	N	H
$\frac{62.0}{12.01}/5.16$	$\frac{24.1}{14.01}/1.72$	$\frac{13.9}{1.01}/13.8$

*Award **[2]** for above.*

No penalty for use of whole number atomic masses.

If atomic numbers used then only mark for % of H can be awarded.

*If H % and calculation missing, award **[1]**, and last mark cannot be scored.*

If H % calculation incorrect apply ECF.

C_3NH_8; 3

*Correct empirical formula scores **[3]**.*

(ii) the average mass of a <u>molecule</u>;

compared to 1/12 of (the mass of) one atom of ^{12}C/compared to C-12 taken as 12;

OR

$$\frac{\text{average mass of a molecule}}{\text{mass of 1/12 of one atom of } {}^{12}\text{C}}$$ 2

*Award **[2]** for the equation above.*

(iii) $C_6N_2H_{16}$; 1

[6]

65. (i)

C	N	H
$\frac{62.0}{12.01}/5.16$	$\frac{24.1}{14.01}/1.72$	$\frac{13.9}{1.01}/13.8$

*Award **[2]** for above.*

No penalty for use of whole number atomic masses.

If atomic numbers used then only mark for % of H can be awarded.

*If H % and calculation missing, award **[1]**, and last mark cannot be scored.*

If H % calculation incorrect apply ECF.

C_3NH_8; 3

*Correct empirical formula scores **[3]**.*

(ii) the average mass of a molecule;
compared to 1/12 of (the mass of) one atom of ^{12}C/compared to C-12 taken as 12;

OR

$$\frac{\text{average mass of a molecule}}{\text{mass of 1/12 of one atom of } {}^{12}\text{C}}$$ 2

*Award **[2]** for the equation above.*

(iii) $C_6N_2H_{16}$; 1

[6]

66. 60.0 dm^3 CO_2;

80.0 dm^3 H_2O;

20.0 dm^3 O_2; 3

Apply –1(U).

[3]

67. overall there will be no change to the pressure;
double absolute temperature and the pressure doubles;
double volume and the pressure halves;

Apply ECF if points 2 and 3 are incorrect.

OR

Use PV = nRT, Since n and R are constant;
V and T are both doubled;
P will remain unchanged;

OR

OWTTE *for mathematical interpretation*

e.g. T α P, therefore 2P;

V α 1/P, therefore ½P;

No change to P, ½P×2P = P; 3

68. (i) n(C)(= n(CO_2) = 2.68 g÷44.01 g mol^{-1}) = 0.0609 mol;

n(H)(= 2×n(H_2O) = 0.657 g÷18.02 g mol^{-1}) = 0.0729 mol;

m(C) = 0.0609 mol×12.01 g mol^{-1} = 0.731 g

and m(H) = 0.0729 mol×1.01 g mol^{-1} = 0.0736 g;

m(O) = (1.00 – 0.731 – 0.0736)g = 0.195g;

n(C)	n(H)	n(O)
0.0609	0.0730	0.195
		16.00
0.0609	0.0730	0.0122
0.0609	0.0730	0.0122
0.0122	0.0122	0.0122
4.99	5.98	1.00;

empirical formula: C_5H_6O; 6

*For C_5H_6 award **[4 max]**.*

Steps used to arrive at the correct amounts (in moles) are required for full marks.

(ii) M(crocetin) = 98.5 g÷0.300 mol = 328 (g mol^{-1});

$(\frac{328}{82.11} = 4)$

molecular formula: $C_{20}H_{24}O_4$; 2

ECF from (i).

[8]

69. (i) $NH_3(aq) + HCl(aq) \rightarrow NH_4Cl(aq)$; 1

States not required for mark

(ii) n(HCl) = cV = 0.100 mol dm^{-3}×0.0250 dm^3 = 0.00250 mol;

n(NH_3) = n(HCl) = 0.00250 mol; 2

ECF

(iii) (*M* (NH_3) = 14.01 + 3(1.01) =) 17.04/17.0 (g mol^{-1});

m(NH_3) = 0.00250 mol×17.04g mol^{-1} = 0.0426g/0.0425g; 2

ECF

[5]

70. empirical formula = CN;

Working must be shown to get point.

M_r = 51.9 (g mol^{-1});

:N≡C—C≡N:; 3

[3]

71. (a) to prevent (re)oxidation of the copper/*OWTTE*; 1

(b) number of moles of oxygen = $\frac{1.60}{16.00}$ = 0.10;

number of moles of copper = $\frac{6.35}{63.55}$ = 0.10;

empirical formula = Cu (0.10) : O (0.10) = CuO; 3

Allow ECF.

*Award **[1]** for CuO with no working.*

Alternate solution

$\frac{6.35}{7.95}$ = 79.8% $\frac{1.60}{7.95}$ = 20.2%

$\frac{70.8}{63.5}$ = 1.25 $\frac{20.2}{16}$ = 1.29

(c) $H_2 + CuO \rightarrow Cu + H_2O$; 1

Allow ECF.

(d) (black copper oxide) solid turns red/brown;

condensation/water vapour (on sides of test tube); 2

Accept change colour.

*Do **not** accept reduction of sample size.*

[7]

72. (a) $n(Cu_2O) = 10.0\times10^3 \div 143.1 = 69.9$ mol;

$n(Cu_2S) = 5.00\times10^3 \div 159.16 = 31.4$ mol;

Penalise failure to convert kg → g once only.

Cu_2S is the limiting reagent; 3

ECF from above answers.

(b) $n(Cu) = 6\times n(Cu_2S) = 6\times31.4 = 188$ mol;

$m(Cu) = 188\times63.55 = 11900 – 12000$ g/11.9 – 12.0 kg; 2

If Cu_2O given in (a), allow $3\times n(Cu_2O)$ and $3\times n(Cu_2O)\times63.55$.

Allow ECF from (a).

[5]

73. $n(Fe_2O_3) = 30\times10^3 \div 159.7 / n(Fe_2O_3) = 188$ mol;

$n(C) = 5.0\times10^3 \div 12.01 / n(C) = 416$ mol;

Fe_2O_3 is the limiting reagent or implicit in calculation;

$n(Fe) = 2\times n(Fe_2O_3) = 2\times188 = 376$ mol;

$m(Fe) = 376\times55.85 = 21$ kg;

Accept 2 sig. fig. or 3 sig. fig., otherwise use – 1(SF).

*Correct final answers score **[5]**.*
Allow ECF.

[5]

74. (a) $M(BaSO_4)$ (= 137.34 + 32.06 + 4(16.00)) = 233.40 (g mol^{-1});
Accept 233.4 but not 233

n($BaSO_4$) $\left(=\frac{0.672\,g}{233.40\,g\,mol^{-1}}\right)$ = 0.00288 / 2.88×10^{-3}(mol); 2
ECF from M value

(b) n (alkali metal sulfate) = 0.00288 / 2.88×10^{-3}(mol); 1
ECF

(c) $M=\left(\frac{m}{n}=\frac{0.502\,g}{0.00288\,mol}=\right)$ 174.31 / 174.3 / 174;
ECF

units: g mol^{-1}; 2

(d) ($2(A_r)$ + 32 + 4(16) = 174, thus) A_r = 39 / $A_r = \left(\frac{(174-(32+(4\times16)}{2}\right)$ =39;
Accept answer between 38.9 and 39.2
ECF
potassium/K;
ECF from A_r value

2

(e) $K_2SO_4(aq) + BaCl_2(aq) \rightarrow BaSO_4(s) + 2KCl(aq)$ 2
*Award **[1]** for balanced equation and **[1]** for state symbols*
ECF if another alkali metal arrived at in (d)
Accept net ionic equation
*If no answer arrived at in (d), but correct equation given involving any alkali metal, then award **[1 max]***

[9]

75. (a) 0.600 mol $Al(OH)_3 \equiv (1.5)(0.600)$ mol H_2SO_4/0.900 mol H_2SO_4 needed, but only 0.600 mol used;
H_2SO_4 limiting reactant; 2
Some working must be shown in order to score the second point.

(b) 0.200 mol $Al_2(SO_4)_3$;
68.4(g); 2
Penalize incorrect units.

(c) 0.200 mol; 1
Use ECF from (a).

(d) A Brønsted-Lowry acid is a proton/H^+ donor;
A Lewis base is an electron-pair donor; 2

(e) H_2CO_3 and carbonic acid/CH_3COOH and ethanoic acid; 1
Accept any other weak acid and correct formula.

[8]