AS LEVEL CHEMISTRY

TOPIC 2 – AMOUNT OF SUBSTANCE

TEST

Answer all questions

Max 50 marks

Name ……..
Mark ……../50 ……....% Grade ……

SECTION A

1. Ammonium sulfate reacts with sodium hydroxide to form ammonia, sodium sulfate and water as shown in the equation below.

$$(NH_4)_2SO_4(s) + 2NaOH(aq) \rightarrow 2NH_3(g) + Na_2SO_4(aq) + 2H_2O(l)$$

(a) A 3.14 g sample of ammonium sulfate reacted completely with 39.30 cm^3 of a sodium hydroxide solution.

(i) Calculate the amount, in moles, of $(NH_4)_2SO_4$ in 3.14 g of ammonium sulfate.

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(2)

(ii) Hence calculate the amount, in moles, of sodium hydroxide which reacted.

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(1)

(iii) Calculate the concentration, in mol dm^{-3}, of the sodium hydroxide solution used.

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(1)

(b) Calculate the percentage atom economy for the production of ammonia in the reaction between ammonium sulfate and sodium hydroxide.

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(2)

(c) Ammonia is manufactured by the Haber Process.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

Calculate the percentage atom economy for the production of ammonia in this process.

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(1)

(d) A sample of ammonia gas occupied a volume of 1.53×10^{-2} m^3 at 37 °C and a pressure of 100 kPa.
(The gas constant $R = 8.31$ J K^{-1} mol^{-1})

Calculate the amount, in moles, of ammonia in this sample.

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(3)

(e) Glauber's salt is a form of hydrated sodium sulfate that contains 44.1% by mass of sodium sulfate. Hydrated sodium sulfate can be represented by the formula $Na_2SO_4.xH_2O$ where x is an integer. Calculate the value of x.

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(3)
(Total 13 marks)

2. Norgessaltpeter decomposes on heating as shown by the following equation.

$$2Ca(NO_3)_2(s) \longrightarrow 2CaO(s) + 4NO_2(g) + O_2(g)$$

A sample of Norgessaltpeter was decomposed completely.

The gases produced occupied a volume of 3.50×10^{-3} m^3 at a pressure of 100 kPa and a temperature of 31 °C.
(The gas constant $R = 8.31$ J K^{-1} mol^{-1})

(i) Calculate the total amount, in moles, of gases produced.

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(3)

(ii) Hence calculate the amount, in moles, of oxygen produced.

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(1)
(Total 4 marks)

3. Potassium carbonate can also occur as a hydrated compound, $K_2CO_3.xH_2O$.
Analysis of this hydrated compound showed that it contained 11.5% by mass of water.
Determine the value of x. Show your working.

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(Total 2 marks)

4. The element nitrogen forms compounds with metals and non-metals.

(a) Calcium nitride contains 81.1% by mass of the metal.
Calculate the empirical formula of calcium nitride.
Show your working.

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(3)

(b) Write an equation for the reaction between silicon and nitrogen to form silicon nitride, Si_3N_4

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(1)
(Total 4 marks)

5. The correct technique can improve the accuracy of a titration.

(a) State why it is important to fill the space below the tap in the burette with solution **A** before beginning an accurate titration.

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(1)

(b) Suggest **one** reason why a 250 cm^3 conical flask is preferred to a 250 cm^3 beaker for a titration.

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(1)

(c) During a titration, a chemist rinsed the inside of the conical flask with deionised water. The water used for rinsing remained in the conical flask.

(i) Give **one** reason why this rinsing can improve the accuracy of the end-point.

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(1)

(ii) Explain why the water used for rinsing has **no** effect on the accuracy of the titre.

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(1)

(d) Suggest **one** reason why repeating a titration makes the value of the average titre more reliable.

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(1)

(Total 5 marks)

6. (a) Sodium hydrogencarbonate ($NaHCO_3$) can also be used to neutralise ethanoic acid spillages. The equation for this reaction is shown below.

$$CH_3COOH + NaHCO_3 \longrightarrow CH_3COONa + H_2O + CO_2$$

State the ideal gas equation.

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(1)

(b) There are several methods by which ethanoic acid is synthesised on an industrial scale. One method is the oxidation of butane in the presence of metal ion catalysts.
Balance the equation given below which summarises this reaction.

$$.....C_4H_{10} + ...O_2 \longrightarrow .....CH_3COOH + ...H_2O$$

(1)

(c) A second method by which ethanoic acid is synthesised involves the oxidative fermentation of ethanol in the presence of bacteria. The equation representing this reaction is given below.

$$C_2H_5OH + O_2 \longrightarrow CH_3COOH + H_2O$$

In a small scale experiment using this second method it was found that 23.0 g of ethanol produced only 4.54 g of ethanoic acid. Calculate the percentage yield for this experiment.

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(2)
(Total 4 marks)

7. Indium forms a compound **X** with hydrogen and oxygen. Compound **X** contains 69.2% indium and 1.8% hydrogen by mass.
Calculate the empirical formula of compound **X**.

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(3)
(Total 3 marks)

8. (a) The manufacturer of vinegar buys concentrated ethanoic acid as a 15.0 mol dm^{-3} solution. In case of an accidental spillage of this ethanoic acid the manufacturer always has sodium carbonate readily available to neutralise the acid. The equation for this reaction is shown below.

$$2CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3COONa + H_2O + CO_2$$

(i) Calculate the amount, in moles, of ethanoic acid in 10.0 cm^3 of a 15.0 mol dm^{-3} solution.

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(1)

(ii) Use your answer from part (i) to calculate the amount, in moles, of sodium carbonate needed to react completely with this amount of ethanoic acid.

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(1)

(iii) Use data from the Periodic Table to calculate the relative formula mass of sodium carbonate. Give your answer to the appropriate precision.

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(1)

(iv) Use your answers from parts (ii) and (iii) to determine the minimum mass of sodium carbonate needed to react completely with 10.0 cm^3 of the 15.0 mol dm^{-3} solution of ethanoic acid.

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(1)

(b) State **one** hazard when using concentrated ethanoic acid and **one** safety precaution you would take to minimise this hazard.

Hazard .....

Precaution .....

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(1)

(Total 5 marks)

9. (a) A solution of barium hydroxide is often used for the titration of organic acids. A suitable indicator for the titration is thymol blue. Thymol blue is yellow in acid and blue in alkali. In a titration a solution of an organic acid was added from a burette to a conical flask containing 25.0 cm^3 of a barium hydroxide solution and a few drops of thymol blue.

(i) Describe in full the colour change at the end-point of this titration.

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(1)

(ii) Thymol blue is an acid. State how the average titre would change if a few cm^3, rather than a few drops, of the indicator were used by mistake in this titration.

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(1)

(iii) Barium hydroxide is toxic. Suggest **one** safety precaution you would take to minimise this hazard when wiping up a spillage of barium hydroxide solution.

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(1)

(iv) Suggest **one** reason why a 250 cm^3 conical flask is preferred to a 250cm^3 beaker for a titration.

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(1)

(v) Suggest **one** reason why repeating a titration can improve its reliability

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(1)

(b) Solubility data for barium hydroxide and calcium hydroxide are given in the table below.

Compound	Solubility at 20 °C / g dm^{-3}
barium hydroxide	38.9
calcium hydroxide	1.73

(i) Use the data given in the table to calculate the concentration, in mol dm^{-3}, of a saturated solution of calcium hydroxide (M_r = 74.1) at 20°C.

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(1)

(ii) Suggest **one** reason why calcium hydroxide solution is **not** used in the titration of a 0.200 mol dm^{-3} solution of an acid.

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(1)

(Total 7 marks)

SECTION B

10. An equation for the incomplete combustion of butane in oxygen is

$$C_4H_{10} + 4\tfrac{1}{2}O_2 \rightarrow 4CO + 5H_2O$$

The volume in dm^3 of oxygen at 295 K and 100 kPa required to burn 0.1 mol of butane to form steam and carbon monoxide only is

A 8.6

B 11

C 12

C 16

(Total 1 mark)

11. Silver oxide, Ag_2O, can be reduced by passing hydrogen gas over the heated oxide. The maximum mass of silver that could be obtained from 2.32 g of silver oxide is

A 2.02 g

B 2.06 g

C 2.12 g

D 2.16 g

(Total 1 mark)

12. The removal of silicon dioxide with limestone in the Blast Furnace can be represented by the following equation.

$$CaCO_3(s) + SiO_2(s) \rightarrow CaSiO_3(l) + CO_2(g)$$

The volume of carbon dioxide, measured at 298 K and 1.01×10^5 Pa, formed in this reaction during the removal of 1.00 tonne (1000 kg) of silicon dioxide is

A 24.5 dm^3

B 408 dm^3

C 24.5 m^3

D 408 m^3

(Total 1 mark)