

Name:	Target Grade:	Actual Grade:
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MOLE CONCEPT MCQ and STRUCTURED QUESTIONS

READ THESE INSTRUCTIONS FIRST

INSTRUCTIONS TO CANDIDATES

1. Find a quiet, comfortable spot free place from distractions.
2. Spend one minute on each mark.
3. Time yourself for every single question.
4. Every chapter has their own question types. Ensure that you know the different question type for each chapter.
5. Make a conscientious effort to remember your mistakes, especially in terms of answering techniques. E.g Take a picture for the mistakes that you made, keep it in a photo album, and revise it over and over again.
6. Highlight question types that you tend to keep making mistakes and review them nearing exams.
7. Always review the common questions and question type that you tend to make mistakes nearing exams.
8. During exams, classify the question type and recall what you have learnt, how you need to analyse the questions for the different question type, what you need to take note of and answer with the correct answering techniques!

✦ Wishing you all the best for this test!

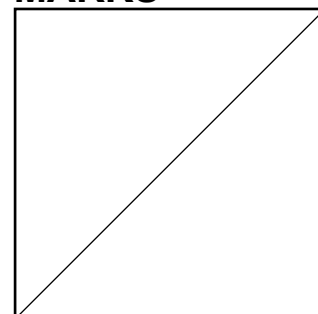
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If you are struggling in this paper, means you need to work harder!

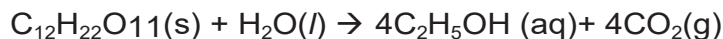
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MARKS



MOLE CONCEPT MCQ**Paper 1**

- 1 When sugar, C₁₂H₂₂O₁₁, (M_r = 342) is fermented using yeast, the following reaction takes place.



1kg of sugar is completely fermented.

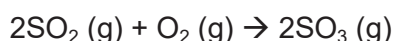
Which expression shows the volume of carbon dioxide produced?

- A $\frac{342 \times 4 \times 24}{1000} \text{ dm}^3$
- B $\frac{1000 \times 24}{342 \times 4} \text{ dm}^3$
- C $\frac{342 \times 24}{1000 \times 4} \text{ dm}^3$
- D $\frac{1000 \times 4 \times 24}{342} \text{ dm}^3$
- 2 A sample of nitrogen gas contains the same number of atoms as found in 4.00 g of methane gas.
- What is the mass of the sample of nitrogen gas?
- A 7.00 g
- B 14.0 g
- C 17.5 g
- D 35.0 g
- 3 In an experiment carried out at room conditions, 1.0 dm³ of carbon dioxide was collected when an excess of dilute hydrochloric acid was added to 5.0 g of calcium carbonate.



What is the percentage yield of carbon dioxide gas?

- A 4.16%
- B 12.0%
- C 41.6%
- D 83.3%
- 4 What is the total volume of gas, measured at room temperature and pressure, that remains if 20 cm³ of sulfur dioxide reacts with 20 cm³ of oxygen to form sulfur trioxide?



- A 10 cm³
- B 20 cm³
- C 30 cm³
- D 60 cm³

- 5 What is the maximum concentration of H^+ ions in 0.250 mol/dm^3 of phosphoric(V) acid, H_3PO_4 ?
- A 0.125 mol/dm^3
B 0.250 mol/dm^3
C 0.500 mol/dm^3
D 0.750 mol/dm^3
- 6 Heating iron in dry chlorine gas results in the formation of an iron(II) chloride. Experimental determination gives a reading of 34.5% by mass of iron in the Iron(II) chloride formed. What is the charge of the iron in the chloride?
- A 2-
B 2+
C 3-
D 3+
- 7 The formula for hydrated copper(II) nitrate is $\text{Cu}(\text{NO}_3)_2 \cdot x \text{H}_2\text{O}$. It contains 36.5% water of crystallization by mass.
- What is the value of x?
- A 4
B 5
C 6
D 7
- 8 Element X is found in Group IV of the Periodic table. Which of the following could not be a formula for a compound of X?
- A XO
B XO_2
C XO^{2-}
D $^3\text{XO}_4$
- 9 Which volume of 1.0 mol/dm^3 hydrochloric acid is required to react completely with 1.25 g of zinc carbonate?
- A 10 cm^3
B 20 cm^3
C 100 cm^3
D 200 cm^3
- 10 An 8 g sample of oxygen atoms contains the same number of atoms as 16 g of element X. What is X?
- A helium
B sodium
C sulfur
D xenon

- 11 When hydrogen peroxide is used as a bleaching agent, it decomposes to form water and oxygen.



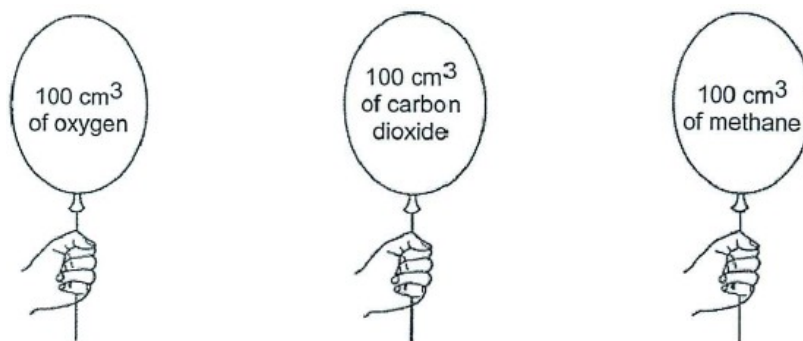
When 68g of hydrogen peroxide decomposes, the volume of oxygen gas collected under room temperature and pressure is 1200 cm³.

What is the percentage purity of hydrogen peroxide?

- A 2.5 %
B 5.0 %
C 10.0 %
D 15.0 %
- 12 The compound S₂O₇ reacts with water to produce sulfuric acid and oxygen only.
- What volume of oxygen, measured at room temperature and pressure, is produced when 0.704 g of S₂O₇ is reacted?

- A 48 cm³
B 96 cm³
C 192 cm³
D 384 cm³

- 13 The diagram shows three balloons filled with different gases held by students.



Which statements are correct?

- 1 The number of moles of gases in the 3 balloons is the same.
 - 2 The number of molecules in the 3 balloons is different.
 - 3 The mass of gases in the 3 balloons is different.
- A 1 and 2 only
B 1 and 3 only
C 2 and 3 only
D 1, 2 and 3

- 14 1.97 g of an unknown metal carbonate, MCO_3 , reacts completely with 50.0 cm³ of 0.400 mol/dm³ hydrochloric acid.

What is the relative atomic mass of **M**?

- A 35.0
 B 94.5
 C 137
 D 150
- 15 Ozone, a gas found in stratosphere, helps to filter the harmful ultraviolet rays from the sun. CFCs from aerosol sprays can cause the ozone layer to decompose as follows:

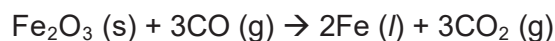


Which one of the following statements is correct at room temperature and pressure?

- A 2 mol of ozone produce 9×10^{23} oxygen molecules.
 B 24 dm³ of ozone produce 24 dm³ of oxygen.
 C 48 dm³ of ozone produces 32 g of oxygen.
 D 48 g of ozone produce 48 g of oxygen.
- 16 Chlorine gas is a severe irritant to the eyes and respiratory system. The maximum safe toleration level of chlorine gas is 0.005 mg/dm³.

How many molecules of chlorine gas are present in 1 dm³ of air at this toleration level?

- A $\frac{0.005}{6 \times 10^{23}} \times 71$
 B $\frac{0.005}{1000} \times \frac{1}{71} \times 6 \times 10^{23}$
 C $\frac{0.005}{71} \times 6 \times 10^{23}$
 D $\frac{0.005}{1000} \times 71 \times 6 \times 10^{23}$
- 17 The equation for the reduction of iron ore in the blast furnace is shown below.

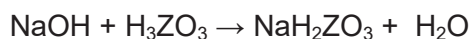


When 20 tonnes of the iron ore were reduced, 7 tonnes of molten iron were produced.

What is the percentage yield of this reduction?

- A 17.5 %
 B 54 %
 C 50 %
 D 70 %

- 18 During the electrolysis of an aqueous solution of a *cerium* salt, 70 g of *cerium* ($A_r = 140$) is deposited at the cathode by 1 mole of electron. What is the formula of the cerium ion?
- A Ce^+
B Ce^{2+}
C Ce^{3+}
D Ce^{4+}
- 19 A solution contains 12.60 g/dm^3 of the acid H_3ZO_3 . 25.0 cm^3 of this solution reacted with an equal volume of 0.100 mol/dm^3 NaOH as shown in the equation.



What is element Z?

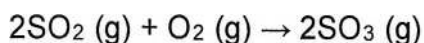
- A arsenic
B nitrogen
C silicon
D sulfur
- 20 A sample of insecticide DDT, $C_{14}H_9Cl_5$, was found to contain 0.120 g of carbon. What mass of chlorine was present in the sample?
- A 0.127 g
B 0.253 g
C 0.994 g
D 1.01 g
- 21 Which of the following contains the greatest number of atoms?
- A 0.5 moles of carbon dioxide
B 1.0 moles of carbon monoxide
C 1.5 moles of nitrogen gas
D 2.0 moles of argon gas
- 22 Which of the following chlorides, when dissolved in water, will give the greatest number of ions?
- A 1.0 moles of $MgCl_2$
B 1.0 moles of PCl_3
C 2.0 moles of $NaCl$
D 2.0 moles of SCl_2

- 23 The chemical formulae of four acids is shown below.

Which acid has the highest percentage by mass of carbon?

- A HCOOH
- B CH₃COOH
- C CH₃CH₂COOH
- D CH₃CH₂CH₂COOH

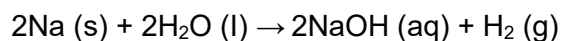
- 24 In the Contact Process, sulfur dioxide reacts with oxygen to form sulfur trioxide according to the equation below.



30 cm³ of sulfur dioxide was reacted with 35 cm³ of oxygen under suitable conditions in a closed container.

Calculate the total volume of gases left in the closed container at the end of the reaction.

- A 25 cm³
 - B 30 cm³
 - C 50 cm³
 - D 70 cm³
- 25 When sodium is reacted with water, sodium hydroxide and hydrogen are formed according to the equation below.



23 g of impure sodium was reacted with water and 10 dm³ of hydrogen was formed.

Which of the following shows the mass of sodium in the impure sample?

- A $\frac{12}{10} \times 23$
- B $\frac{24}{10} \times 23$
- C $\frac{10}{12} \times 23$
- D $\frac{10}{24} \times 23$

- 26 The following results are obtained from an experiment involving the reduction of an oxide of lead to lead metal.

Mass of test tube	= 21.28 g
Mass of test tube + lead oxide	= 27.26 g
Mass of test tube + lead	= 26.46 g

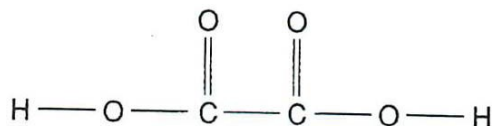
What is the empirical formula of this oxide of lead?

- A PbO
B Pb₂O₃
C PbO₂
D Pb₃O₄
- 27 Which aqueous acid neutralizes the greatest volume of aqueous sodium hydroxide?
- A 1 dm³ of H₂SO₄ of concentration 4 mol/dm³
B 2 dm³ of H₃PO₄ of concentration 2 mol/dm³
C 3 dm³ of HNO₃ of concentration 2 mol/dm³
D 4 dm³ of CH₃COOH of concentration 1 mol/dm³
- 28 5 g of barium sulfate is contaminated with barium carbonate. The mixture is added to excess nitric acid and filtered. The mass of the residue and filtrate is found to be 2.8 g and 9 g respectively.

What is the percentage purity of barium sulfate?

- A $\frac{2.2}{5} \times 100$
B $\frac{2.8}{5} \times 100\%$
C $\frac{5}{9} \times 100\%$
D $\frac{9}{5} \times 100\%$

- 29 The structure of oxalic acid is shown below.



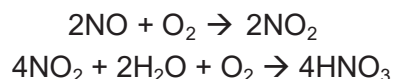
A 25.0 cm³ solution of oxalic acid reacts completely with 15.0 cm³ of 2.5 mol/dm³ sodium hydroxide.

What is the concentration of the oxalic acid solution?

- A 0.667 mol/dm³
 B 0.750 mol/dm³
 C 1.33 mol/dm³
 D 1.50 mol/dm³
- 30 Which sulfide contains the greatest mass of sulfur in a 10 g sample?

sulfide	formula	mass of one mole /g
A	NiS	91
B	FeS ₂	120
C	MoS ₂	160
D	PbS	239

- 31 Two of the reactions used in the manufacture of nitric acid, HNO₃, are shown.



What is the maximum number of moles of nitric acid which could be formed from one mole of nitrogen monoxide, NO?

- A 0.5
 B 1.0
 C 2.0
 D 4.0
- 32 A piece of chalk has a mass of 23.0 g. Chalk is impure calcium carbonate. When analysed, the chalk is found to contain 0.226 moles of calcium carbonate. What is the percentage purity of the piece of chalk?
- A 0.983%
 B 1.02%
 C 77.0%
 D 98.3%

- 33 Compound P is the only substance formed when two volumes of ammonia gas react with one volume of carbon dioxide gas (both volumes being measured at r.t.p.).

What is the formula of P?

- A $\text{NH}_2\text{CO}_2\text{NH}_4$
- B $(\text{NH}_2)_2\text{CO}$
- C $\text{NH}_4\text{CO}_2\text{NH}_4$
- D $(\text{NH}_4)_2\text{CO}_3$

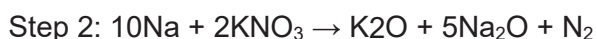
- 34 When sugar ($M_r = 342$) is fermented using yeast, the following reaction takes place.



What volume of carbon dioxide, at r.t.p., would be produced by the complete fermentation of 1 kg of sugar?

- | | |
|--|--|
| <p>A $\frac{342 \times 4 \times 24}{1000} \text{ dm}^3$</p> | <p>B $\frac{1000 \times 24}{342 \times 4} \text{ dm}^3$</p> |
| <p>C $\frac{342 \times 24}{1000 \times 4} \text{ dm}^3$</p> | <p>D $\frac{1000 \times 4 \times 24}{342} \text{ dm}^3$</p> |

- 35 On collision, airbags in cars inflate rapidly due to the production of nitrogen. The nitrogen is formed, in two consecutive steps, according to the following equations.



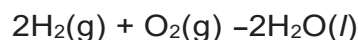
What is the **total** number of moles of nitrogen gas that can be produced from one mole of sodium azide, NaN_3 ?

- A 1.5
- B 1.6
- C 3.2
- D 4.0

- 36 One mole of a sample of hydrated sodium sulfide contains 162 g of water of crystallisation. What is the correct formula of this compound?

- A $\text{Na}_2\text{S} \cdot 3\text{H}_2\text{O}$
- B $\text{Na}_2\text{S} \cdot 5\text{H}_2\text{O}$
- C $\text{Na}_2\text{S} \cdot 7\text{H}_2\text{O}$
- D $\text{Na}_2\text{S} \cdot 9\text{H}_2\text{O}$

- 37 Hydrogen reacts with oxygen as shown in the equation below.



How much gas will remain if 2 dm³ of hydrogen are reacted with 1 dm³ of oxygen at room temperature?

- A 0 dm³
 - B 1 dm³
 - C 2 dm³
 - D 3 dm³
- 38 The complete combustion of 20 cm³ of a gaseous alkane, Y, requires 130 cm³ of oxygen. Both volumes were measured at r.t.p..

What could be the identity of Y?

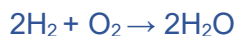
- A butane
 - C methane
 - B ethane
 - D Propane
- 39 1.0 mole of Cu₃FeS₃ and 1.0 mole of O₂ are allowed to react according to the equation.



Which of the following is true?

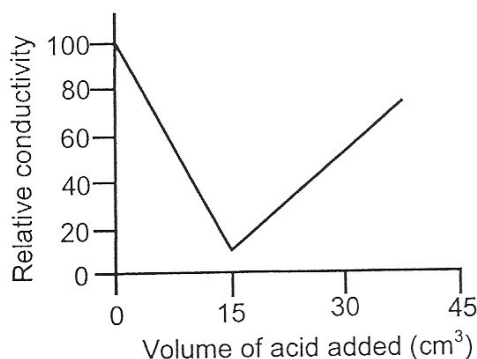
- A 0.286 mole of Cu₃FeS₃ is in excess
 - B 0.714 mole of Cu₃FeS₃ is in excess
 - C 5.0 moles of O₂ is in excess
 - D no reagent is in excess
- 40 Which one of the following has the most number of atoms?
- A 10 g nitrogen gas
 - B 10 g magnesium
 - C 10 g oxygen gas
 - D 10 g carbon dioxide

- 41 A gas contains 46.2% of carbon and 53.8% of nitrogen. Under room temperature and pressure (r.t.p.), its volume and mass are 6 dm³ and 13 g respectively. What is the molecular formula of the gas?
- A C₃N₂
B C₂N₂
C CN
D C₃N₃
- 42 A mixture of 8.0 g of hydrogen with 8.0 g of oxygen is ignited.



What is the mass of water formed?

- A 9.0 g
B 16.0 g
C 18.0 g
D 36.0 g
- 43 The complex ion [Ag(NH₃)_x]⁺ consists of 76% by mass of silver. What is the value of x?
- A 5
B 4
C 3
D 2
- 44 The empirical formula of a liquid compound is known to be C₂H₄O. What other information is needed to work out its molecular formula?
- A percentage composition of the compound
B relative molecular mass of the compound.
C density of the compound
D volume occupied by one mole of the compound
- 45 20.0 cm³ of KOH solution was titrated with 0.200 mol dm⁻³ H₂SO₄ solution in a conductivity cell. The data obtained was plotted to give the graph shown below.



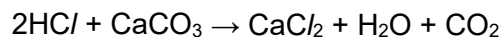
What is the concentration of the KOH solution?

- A 0.300 mol dm⁻³
- B 0.150 mol dm⁻³
- C 0.120 mol dm⁻³
- D 0.075 mol dm⁻³

46 Which ion is present in the highest concentration in a 2 mol dm⁻³ aqueous solution of sodium sulfate?

- A hydrogen ions, H⁺(aq)
- B hydroxide ions, OH⁻(aq)
- C sodium ions, Na⁺(aq)
- D sulfate ions, SO₄²⁻(aq)

47 The reaction between hydrochloric acid and calcium carbonate is as shown:



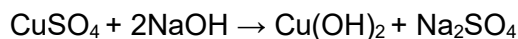
What volume of 1.0 mol dm⁻³ hydrochloric acid is needed to react completely with 1.0 g of calcium carbonate ($M_r = 100$)?

- A 10 cm³
- B 20 cm³
- C 100 cm³
- D 200 cm³

48 Which of the following is the correct ratio of the number of atoms in 112 g of gaseous nitrogen to the number of atoms in 90 g of ethane (C₂H₆)?

- A 1 : 1
- B 1 : 3
- C 1 : 6
- D 1 : 12

- 49 In an experiment, 16.0 cm^3 of 1.0 mol dm^{-3} aqueous copper(II) sulfate was mixed with 8.0 cm^3 of 1.0 mol dm^{-3} of aqueous sodium hydroxide.



What did the reaction vessel contain when the reaction was complete?

- A a colourless solution
 - B a blue precipitate and a blue solution
 - C a blue precipitate and a colourless solution
 - D a white precipitate and a blue solution
- 50 The formula of a sodium compound in silica gel is $\text{Na}_2\text{Si}_4\text{O}_x$. What is the value of x if the relative molecular mass of the sodium compound is 302?
- A 8
 - B 9
 - C 10
 - D 12
- 51 5 g of element **X** reacted with 8 g of element **Y** to form a compound with the formula XY_2 . Given that 80 is the relative atomic mass of **Y**, what is the relative atomic mass of **X**?
- A 25
 - B 50
 - C 40
 - D 100
- 52 Which of the following has the largest number of atoms?
- A 0.1 mole of oxygen
 - B 0.2 mole of water
 - C 0.3 mole of carbon
 - D 0.4 mole of helium

MOLE CONCEPT STRUCTURED QUESTIONS**Paper 2 Section A**

1 Aspirin tablets have important medical uses.

Aspirin ($C_9H_8O_4$) is made when salicylic acid ($C_7H_6O_3$) reacts with ethanoic anhydride.

The equation for this reaction is $C_7H_6O_3 + C_4H_6O_3 \rightarrow C_9H_8O_4 + CH_3COOH$.

Calculate the **maximum** mass of aspirin that could be made from 100 g of salicylic acid.[1]

- (b) (i) In an experiment, a chemist calculated the maximum yield of aspirin is 400 g. The chemist did the experiment but only made 250 g of aspirin. Calculate the percentage yield of aspirin for this experiment.

Show clearly how you work out your answer and suggest one possible reason why the chemist did not have a percentage yield of 100%.

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

- (ii) Suggest how the use of catalyst might reduce costs in the industrial production of aspirin.

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

- (c) Instant cold packs are used to treat sports injuries.



One type of cold pack has a plastic bag containing water. Inside the bag is a smaller bag containing solid ammonium nitrate. The outer bag is squeezed so that the inner bag bursts.

Explain why the bag becomes cold.

.....

.....

[Total: 7]

- 2** In an experiment, 20.0 cm³ of 0.550 mol/dm³ of barium nitrate was added to excess aqueous sodium sulfate to produce barium sulfate and sodium nitrate.

(a) Calculate the maximum mass of barium sulfate produced.

mass =g

[2]

(b) A mass of 1.92 g of dry barium sulfate was obtained.

Calculate the percentage yield of barium sulfate.

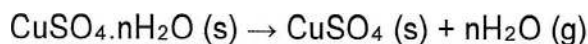
percentage yield =%

[2]

[Total: 4]

- 3** The formula of hydrated copper(II) sulfate is CuSO₄.nH₂O, where n is a number to be determined.

When hydrated copper(II) sulfate is heated, anhydrous copper(II) sulfate, CuSO₄, is formed and water vapour is given off according to the equation below.



2.00 g of hydrated copper(II) sulfate was heated until no further loss in mass was recorded. By the end of the reaction, the mass of the anhydrous copper(II) sulfate was
1.28 g.

(a) State which instrument was used to determine the mass of the solids.

.....[1]

(b) (i) Calculate the number of moles of anhydrous copper(II) sulfate formed.

.....[1]

(ii) Calculate the number of moles of water vapour released.

.....

.....

.....

.....

..... [2]

(iii) Hence, calculate the value of n .

.....

.....[1]

(c) (i) State whether obtaining anhydrous copper(II) sulfate and water from hydrated copper(II) sulfate is a physical or chemical change. Explain your answer.

.....

.....[1]

(ii) Suggest why a gas syringe cannot be used to collect the water vapour produced from this reaction at room temperature and pressure.

.....

.....[1]

[Total: 7]

- 4 2 moles of aqueous silver nitrate was mixed with 3 moles of aqueous sodium chloride. A white solid, silver chloride, was formed together with one other aqueous product.

Filtration was performed on the mixture to separate the solid and the solution.

- (a) (i) Write the balanced chemical equation for this reaction.

.....[1]

- (ii) Hence, write the balanced ionic equation for the same reaction. Include state symbols.

.....[2]

- (b) (i) State which reactant, aqueous silver nitrate or aqueous sodium chloride, is the limiting reagent.

.....[1]

- (ii) Name the substances found in the filtrate after filtration had been completed. Explain your answer.

.....
.....
.....
.....

..... [2]

- (c) Calculate the mass of silver chloride formed from the reaction.

.....

.....[1]

[Total : 7]

5 A photographic plate is made up of a plastic base covered with a layer of 0.50 g silver bromide. After a photograph is taken, 35% of the silver bromide is reduced to silver. The image is then fixed by reacting the remaining silver bromide with aqueous sodium thiosulfate as shown in the equation below.



- (a) What is the mass of silver bromide remaining on the plate after a photograph is taken?

mass of silver bromide =
.....[1]

- (b) How many moles of sodium thiosulfate is needed to fix the plate?

moles of sodium thiosulfate =
.....[2]

- (c) A 100 cm³ sample of 0.200 mol/dm³ sodium thiosulfate is used in the fixing process. Calculate the number of moles of thiosulfate left after the process.

moles of sodium thiosulfate =
.....[2]

(d) Explain using oxidation states, why the silver bromide is said to be reduced to silver.

.....

.....[1]

(e) Silver bromide is a pale yellow insoluble halide salt. Briefly describe how a pure and dry sample of silver bromide can be prepared starting from silver nitrate.

.....

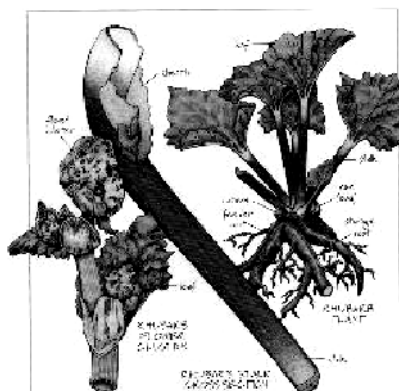
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.....

..... [2]

[Total: 8]

6 The picture below shows the leaf and stem of the rhubarb plant.



[Picture taken from http://northcoastcafe.typepad.com/north_coast_cafe/2004/03/rhubarb_1.html]

A team of scientists interested in studying Rhubarb discovered that rhubarb leaves contained high amounts of substance **X**. Substance **X** can be poisonous to humans.

When comparing two aqueous solutions of hydrochloric acid and substance **X** of the same concentration, it was found that hydrochloric acid has a pH of 1 and substance **X** has a pH of 3. Upon titrating substance **X** with sodium hydroxide, the scientists discovered that one mole of substance **X** reacts with two moles of sodium hydroxide.

The scientists were also interested in the colour pigments present in the Rhubarb leaf. When the leaf is crushed and mixed with the solvent propanone, the coloured pigments are extracted to give a deep green solution. One of the pigments in this solution is chlorophyll.

- (a) Describe what would be observed when calcium carbonate is added to substance **X**. [2]

- (b) Substance **X** has composition 71.1% oxygen, 2.2% hydrogen and 26.7% carbon by mass. Given that the M_r of substance **X** is 90, calculate the molecular formula of substance **X**. [2]

- (c) How would you show that chlorophyll is not the only pigment in the solution? Name and describe the technique used and explain the expected results.

Use diagrams to illustrate your answer. [4]

- 7 (a) Antacid tablets are ingested to provide relief for gastric pains. Antacid tablets containing magnesium carbonate are seldom used nowadays. Instead, magnesium hydroxide is usually used as the active ingredient. Based on the reactions involved, suggest one reason why magnesium hydroxide is preferred to magnesium carbonate. [1]

- (b) Irene took some tablets containing magnesium hydroxide to relieve stomach pains caused by excess hydrochloric acid present in the gastric juice.

- (i) Write a chemical equation for the above reaction. [1]

- (ii) Gastric juice in the stomach contains the equivalent of 100 cm³ of hydrochloric acid of concentration 2.00 mol dm⁻³. If one tablet contains 3.00 g of magnesium hydroxide, calculate the minimum number of tablets required to relieve the stomach pains. [3]

- 8 The following experiment was conducted by the Consumer Association of Singapore to compare the composition of two commercial brands of vinegar.

25.0 cm³ of Brand X vinegar was titrated against 1.00 mol dm⁻³ NaOH solution, using phenolphthalein as an indicator. The equation for neutralisation is as shown below:



The volume of NaOH required for titration was found to be 26.25 cm³.

- (a) Describe the colour change of the indicator at the end point. [1]
-

- (b) (i) Calculate the concentration of ethanoic acid, CH_3COOH present in Brand X vinegar in mol dm^{-3} . [2]

- (ii) Given that the density of Brand X vinegar is 1.05 g cm^{-3} , calculate the percentage by mass of ethanoic acid, CH_3COOH in the vinegar. [2]

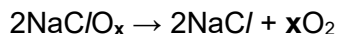
- (c) The prices of Brand X and Brand Y vinegar are given below:

brand	price per bottle	volume of vinegar in 1 bottle (cm^3)	concentration of ethanoic acid (mol dm^{-3})
X	\$4.	125	-
Y	\$8.	250	0.833

Using your answer in (b), explain which brand of vinegar will be a better buy. [2]

9 Sodium forms 2 compounds with chlorine and oxygen.

(a) One mole of NaC and pressure, according to the equation below to produce 36 dm³ of O₂ (one of the compounds) decomposes at room temperature³ of oxygen.



What is the formula of this compound? (Show all the essential working)

[3]

(b) One mole of NaC/O_y (the other compound) reacts with 73.0 g of dilute hydrochloric acid to form 58.5 g of sodium chloride, 18 g of water and 24 dm³ of chlorine at room temperature and pressure.

(i) Calculate the number of moles of hydrochloric acid reacted and sodium chloride, water and chlorine formed. [1]

(ii) Give the chemical equation for the reaction for NaC/O_y. [1]

(iii) Hence, give the formula of this compound. [1]

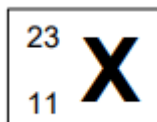
10 In an experiment, 2.76 g of sodium react with an excess amount of gaseous element E. At the end of the experiment, 12.36 g of compound NaE is obtained.

(a) Calculate the mass of gas E reacted with sodium. [1]

- (b) Determine the relative atomic mass of element **E**. [3]

- (c) Identify element **E**. [1]
-

- 11 The diagram below shows the symbol of the atom of element **X**.



- (a) **X** forms a compound with sulfur and oxygen. 12.34 g of this compound contains 5.00 g of sulfur and 3.75 g of oxygen. If the molar mass of the compound is 158 g mol⁻¹. What is the molecular formula of the compound? [4]

- (b) An aqueous solution of this compound reacts with aqueous hydrochloric acid to form an aqueous solution of chloride of **X**, sulfur, sulfur dioxide and water.
- (i) Write the chemical equation including the state symbols for this reaction. [1]
-

(ii) Calculate the maximum mass of sulfur deposited when 4 g of the compound is added to 0.0400 mole aqueous hydrochloric acid. [3]

12 In an experiment, a sample of iron powder was oxidized to form a certain oxide of iron.

(a) Calculate the empirical formula of the oxide if it contained 30% by mass of oxygen. [3]

(b) 0.5 mol of the oxide of iron produced in (a) completely reacted with 109.5 g of dilute hydrochloric acid to form a salt of iron and water.

(i) Calculate the number of moles of hydrochloric acid reacted. [2]

(ii) Write down a balanced chemical equation for this reaction, complete with the state symbols. [2]

(iii) Describe the observations that will be obtained when excess aqueous sodium hydroxide was added gradually to the salt of iron obtained from the reaction. [2]

13 (a) When nitrogen gas was reacted with hydrogen gas at a certain temperature and pressure, ammonia gas was produced. If there were 120 dm^3 (measured at r.t.p.) of ammonia gas produced,

(i) determine the mass of ammonia gas produced. [1]

(ii) calculate the mass of nitrogen present in the ammonia gas produced. [1]

(iii) calculate the number of ammonia molecules produced. [1]

(b) The empirical formula of a certain gas is XY_2 .
The relative atomic mass of **X** and **Y** are 12 and 1 respectively.

(i) If the relative molecular mass of the gas is 42, determine the molecular formula of the gas. [1]

(ii) A sealed cylinder contains 36 dm^3 (measured at r.t.p) of the gas mentioned in (b)(i).
Calculate the mass of **Y** present in the gas. [2]

14 When excess aqueous sodium hydroxide is added gradually to an aqueous solution **X**, a dirty green precipitate which is insoluble in excess aqueous sodium hydroxide is formed. The reaction also forms aqueous chloride **Y**.

(a) State the chemical name of aqueous solution **X** and **Y** respectively. [2]

(b) For every mole of **X** reacted, 2 moles of **Y** are formed. Calculate the mass of **X** reacted if 11.7g of **Y** is produced. [3]

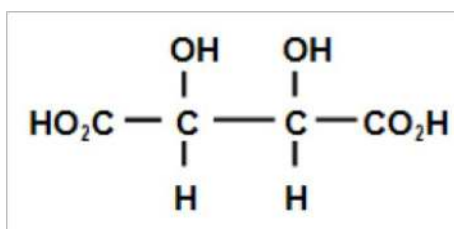
15 **(a)** In an experiment, 25.0 cm³ of 1.0 mol dm⁻³ of barium chloride solution is added to 100 cm³ of 1.0 mol dm⁻³ of sulfuric acid.

(i) Write the balanced chemical equation, including the state symbols, for the reaction between barium chloride and sulfuric acid. [1]

(ii) Show by calculation which substance acts as a limiting reagent. [3]

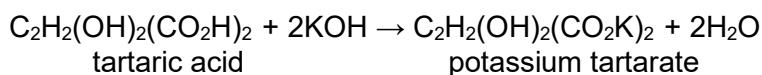
- (iii) Describe briefly how to make pure and dry sodium nitrate crystals in the school laboratory. [4]

16 Tartaric acid is a weak dibasic organic acid that can be extracted from grape juice. It is purified by recrystallization. The structure of tartaric acid is shown below.



- (a) (i) Define weak acid. [1]

- (ii) Tartaric acid reacts with aqueous potassium hydroxide according to the equation shown below.



A test analysis showed that 11.3 g of potassium tartarate was formed when 9.0 g of impure tartaric acid were used. Calculate the percentage purity of tartaric acid. [3]

- (b) All hydrocarbons undergo complete combustion to form carbon dioxide and water only. A 20.0 cm³ sample of a hydrocarbon of formula C_xH₄ required 60.0 cm³ of oxygen for complete combustion. If both volumes are measured at r.t.p., what is the value of x [2]

17 When potassium is burnt in oxygen, it forms potassium peroxide (K_2O_2).

In spaceships, potassium peroxide is dissolved in water to form potassium hydroxide and oxygen. Potassium hydroxide removes carbon dioxide while oxygen is required for breathing.

In a particular spaceship, 13.2 g of potassium peroxide is dissolved in 0.500 dm^3 of water.

(a) Write the balanced chemical equation for the reaction between potassium peroxide and water. [1]

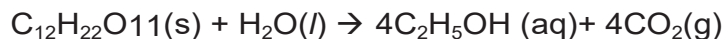
(b) Calculate the number of moles of potassium hydroxide. [2]

(c) Calculate the mass of oxygen gas produced. [1]

(d) Calculate the volume of oxygen gas produced when the gas is cooled to room temperature and pressure. [1]

ANSWER TO MOLE CONCEPT**Paper 1**

- 1 When sugar, $C_{12}H_{22}O_{11}$, ($M_r = 342$) is fermented using yeast, the following reaction takes place.



1kg of sugar is completely fermented.

Which expression shows the volume of carbon dioxide produced?

A $\frac{342 \times 4 \times 24}{1000} \text{ dm}^3$

B $\frac{1000 \times 24}{342 \times 4} \text{ dm}^3$

C $\frac{342 \times 24}{1000 \times 4} \text{ dm}^3$

D $\frac{1000 \times 4 \times 24}{342} \text{ dm}^3$

- 2 A sample of nitrogen gas contains the same number of atoms as found in 4.00 g of methane gas.

What is the mass of the sample of nitrogen gas?

A 7.00 g

B 14.0 g

C 17.5 g

D 35.0 g

- 3 In an experiment carried out at room conditions, 1.0 dm^3 of carbon dioxide was collected when an excess of dilute hydrochloric acid was added to 5.0 g of calcium carbonate.



What is the percentage yield of carbon dioxide gas?

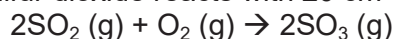
A 4.16%

B 12.0%

C 41.6%

D 83.3%

- 4 What is the total volume of gas, measured at room temperature and pressure, that remains if 20 cm^3 of sulfur dioxide reacts with 20 cm^3 of oxygen to form sulfur trioxide?



A 10 cm^3

B 20 cm^3

C 30 cm^3

D 60 cm^3

- 5 What is the maximum concentration of H^+ ions in 0.250 mol/dm^3 of phosphoric(V) acid, H_3PO_4 ?
- A 0.125 mol/dm^3
B 0.250 mol/dm^3
C 0.500 mol/dm^3
D 0.750 mol/dm^3
- 6 Heating iron in dry chlorine gas results in the formation of an iron(II) chloride. Experimental determination gives a reading of 34.5% by mass of iron in the Iron(II) chloride formed. What is the charge of the iron in the chloride?
- A 2-
B 2+
C 3-
D 3+
- 7 The formula for hydrated copper(II) nitrate is $\text{Cu}(\text{NO}_3)_2 \cdot x \text{H}_2\text{O}$. It contains 36.5% water of crystallization by mass.
- What is the value of x?
- A 4
B 5
C 6
D 7
- 8 Element X is found in Group IV of the Periodic table. Which of the following could not be a formula for a compound of X?
- A XO
B XO_2
C XO^{2-}
D XO_4
- 9 Which volume of 1.0 mol/dm^3 hydrochloric acid is required to react completely with 1.25 g of zinc carbonate?
- A 10 cm^3
B 20 cm^3
C 100 cm^3
D 200 cm^3
- 10 An 8 g sample of oxygen atoms contains the same number of atoms as 16 g of element X. What is X?
- A helium
B sodium
C sulfur
D xenon

- 11 When hydrogen peroxide is used as a bleaching agent, it decomposes to form water and oxygen.



When 68g of hydrogen peroxide decomposes, the volume of oxygen gas collected under room temperature and pressure is 1200 cm³.

What is the percentage purity of hydrogen peroxide?

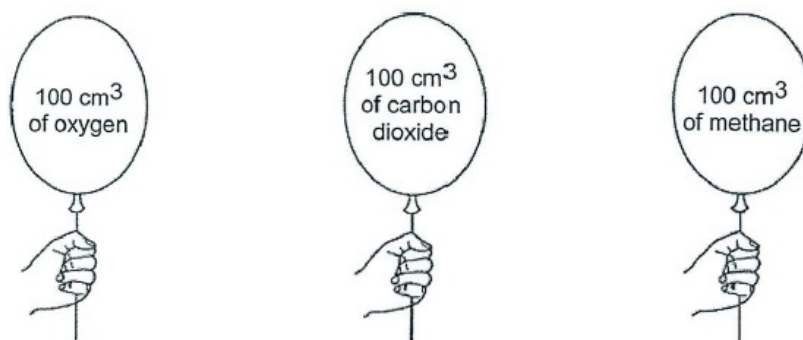
- A 2.5 %
- B 5.0 %**
- C 10.0 %
- D 15.0 %

- 12 The compound S₂O₇ reacts with water to produce sulfuric acid and oxygen only.

What volume of oxygen, measured at room temperature and pressure, is produced when 0.704 g of S₂O₇ is reacted?

- A 48 cm³**
- B 96 cm³
- C 192 cm³
- D 384 cm³

- 13 The diagram shows three balloons filled with different gases held by students.



Which statements are correct?

- 1 The number of moles of gases in the 3 balloons is the same.
- 2 The number of molecules in the 3 balloons is different.
- 3 The mass of gases in the 3 balloons is different.

- A 1 and 2 only
- B 1 and 3 only**
- C 2 and 3 only
- D 1, 2 and 3

- 14 1.97 g of an unknown metal carbonate, MCO_3 , reacts completely with 50.0 cm^3 of 0.400 mol/dm^3 hydrochloric acid.

What is the relative atomic mass of **M**?

- A 35.0
 B 94.5
 C 137
 D 150
- 15 Ozone, a gas found in stratosphere, helps to filter the harmful ultraviolet rays from the sun. CFCs from aerosol sprays can cause the ozone layer to decompose as follows:



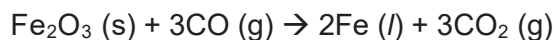
Which one of the following statements is correct at room temperature and pressure?

- A 2 mol of ozone produce 9×10^{23} oxygen molecules.
 B 24 dm^3 of ozone produce 24 dm^3 of oxygen.
 C 48 dm^3 of ozone produces 32 g of oxygen.
 D 48 g of ozone produce 48 g of oxygen.
- 16 Chlorine gas is a severe irritant to the eyes and respiratory system. The maximum safe toleration level of chlorine gas is 0.005 mg/dm^3 .

How many molecules of chlorine gas are present in 1 dm^3 of air at this toleration level?

- A $\frac{0.005}{6 \times 10^{23}} \times 71$
 B $\frac{0.005}{1000} \times \frac{1}{71} \times 6 \times 10^{23}$
 C $\frac{0.005}{71} \times 6 \times 10^{23}$
 D $\frac{0.005}{1000} \times 71 \times 6 \times 10^{23}$

- 17 The equation for the reduction of iron ore in the blast furnace is shown below.



When 20 tonnes of the iron ore were reduced, 7 tonnes of molten iron were produced.

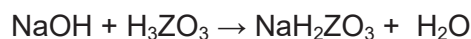
What is the percentage yield of this reduction?

- A 17.5 %
- B 54 %
- C 50 %**
- D 70 %

- 18 During the electrolysis of an aqueous solution of a *cerium* salt, 70 g of *cerium* ($A_r = 140$) is deposited at the cathode by 1 mole of electron. What is the formula of the cerium ion?

- A Ce^+
- B Ce^{2+}**
- C Ce^{3+}
- D Ce^{4+}

- 19 A solution contains 12.60 g/dm^3 of the acid H_3ZO_3 .
 25.0 cm^3 of this solution reacted with an equal volume of 0.100 mol/dm^3 NaOH as shown in the equation.



What is element Z?

- A arsenic**
 - B nitrogen
 - C silicon
 - D sulfur
- 20 A sample of insecticide DDT, $\text{C}_{14}\text{H}_9\text{Cl}_5$, was found to contain 0.120 g of carbon.

What mass of chlorine was present in the sample?

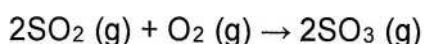
- A 0.127g**
- B 0.253 g
- C 0.994 g
- D 1.01 g

- 21 Which of the following contains the greatest number of atoms?
- A 0.5 moles of carbon dioxide
 - B 1.0 moles of carbon monoxide
 - C 1.5 moles of nitrogen gas**
 - D 2.0 moles of argon gas
- 22 Which of the following chlorides, when dissolved in water, will give the greatest number of ions?
- A 1.0 moles of $MgCl_2$
 - B 1.0 moles of NCI_3
 - C 2.0 moles of NaCl**
 - D 2.0 moles of SCl_2

- 23 The chemical formulae of four acids is shown below.
Which acid has the highest percentage by mass of carbon?

- A HCOOH
- B CH_3COOH
- C CH_3CH_2COOH
- D $CH_3CH_2CH_2COOH$**

- 24 In the Contact Process, sulfur dioxide reacts with oxygen to form sulfur trioxide according to the equation below.

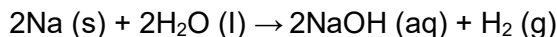


30 cm^3 of sulfur dioxide was reacted with 35 cm^3 of oxygen under suitable conditions in a closed container.

Calculate the total volume of gases left in the closed container at the end of the reaction.

- A 25 cm^3
- B 30 cm^3
- C 50 cm^3**
- D 70 cm^3

- 25 When sodium is reacted with water, sodium hydroxide and hydrogen are formed according to the equation below.



23 g of impure sodium was reacted with water and 10 dm³ of hydrogen was formed.

Which of the following shows the mass of sodium in the impure sample?

- A** $\frac{12}{10} \times 23$
- B** $\frac{24}{10} \times 23$
- C** $\frac{10}{12} \times 23$
- D** $\frac{10}{24} \times 23$
- 26 The following results are obtained from an experiment involving the reduction of an oxide of lead to lead metal.

Mass of test tube	= 21.28 g
Mass of test tube + lead oxide	= 27.26 g
Mass of test tube + lead	= 26.46 g

What is the empirical formula of this oxide of lead?

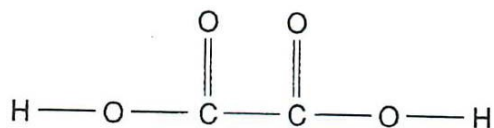
- A** PbO
- B** Pb₂O₃
- C** PbO₂
- D** Pb₃O₄
- 27 Which aqueous acid neutralizes the greatest volume of aqueous sodium hydroxide?
- A** 1 dm³ of H₂SO₄ of concentration 4 mol/dm³
- B** 2 dm³ of H₃PO₄ of concentration 2 mol/dm³
- C** 3 dm³ of HNO₃ of concentration 2 mol/dm³
- D** 4 dm³ of CH₃COOH of concentration 1 mol/dm³

- 28 5 g of barium sulfate is contaminated with barium carbonate. The mixture is added to excess nitric acid and filtered. The mass of the residue and filtrate is found to be 2.8 g and 9 g respectively.

What is the percentage purity of barium sulfate?

- A** $\frac{2.2}{5} \times 100$
- B** $\frac{2.8}{5} \times 100\%$
- C** $\frac{5}{9} \times 100\%$
- D** $\frac{9}{5} \times 100\%$

- 29 The structure of oxalic acid is shown below.



A 25.0 cm³ solution of oxalic acid reacts completely with 15.0 cm³ of 2.5 mol/dm³ sodium hydroxide.

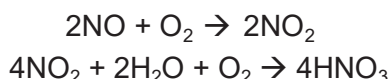
What is the concentration of the oxalic acid solution?

- A 0.667 mol/dm³
- B 0.750 mol/dm³**
- C 1.33 mol/dm³
- D 1.50 mol/dm³

- 30 Which sulfide contains the greatest mass of sulfur in a 10 g sample?

sulfide	formula	mass of one mole /g
A	NiS	91
B	FeS₂	120
C	MoS ₂	160
D	PbS	239

- 31 Two of the reactions used in the manufacture of nitric acid, HNO₃, are shown.



What is the maximum number of moles of nitric acid which could be formed from one mole of nitrogen monoxide, NO?

- A 0.5
- B 1.0**
- C 2.0
- D 4.0

- 32 A piece of chalk has a mass of 23.0 g. Chalk is impure calcium carbonate. When analysed, the chalk is found to contain 0.226 moles of calcium carbonate. What is the percentage purity of the piece of chalk?

- A 0.983%
- B 1.02%
- C 77.0%
- D 98.3%**

- 33 Compound P is the only substance formed when two volumes of ammonia gas react with one volume of carbon dioxide gas (both volumes being measured at r.t.p.).

What is the formula of P?

- A** $\text{NH}_2\text{CO}_2\text{NH}_4$
- B $(\text{NH}_2)_2\text{CO}$
- C $\text{NH}_4\text{CO}_2\text{NH}_4$
- D $(\text{NH}_4)_2\text{CO}_3$

- 34 When sugar ($M_r = 342$) is fermented using yeast, the following reaction takes place.



What volume of carbon dioxide, at r.t.p., would be produced by the complete fermentation of 1 kg of sugar?

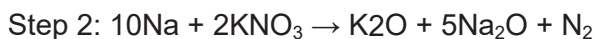
A $\frac{342 \times 4 \times 24}{1000} \text{ dm}^3$

B $\frac{1000 \times 24}{342 \times 4} \text{ dm}^3$

C $\frac{342 \times 24}{1000 \times 4} \text{ dm}^3$

D $\frac{1000 \times 4 \times 24}{342} \text{ dm}^3$

- 35 On collision, airbags in cars inflate rapidly due to the production of nitrogen. The nitrogen is formed, in two consecutive steps, according to the following equations.



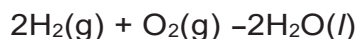
What is the **total** number of moles of nitrogen gas that can be produced from one mole of sodium azide, NaN_3 ?

- A 1.5
- B 1.6**
- C 3.2
- D 4.0

- 36 One mole of a sample of hydrated sodium sulfide contains 162 g of water of crystallisation. What is the correct formula of this compound?

- A $\text{Na}_2\text{S} \cdot 3\text{H}_2\text{O}$
- B $\text{Na}_2\text{S} \cdot 5\text{H}_2\text{O}$
- C $\text{Na}_2\text{S} \cdot 7\text{H}_2\text{O}$
- D $\text{Na}_2\text{S} \cdot 9\text{H}_2\text{O}$**

- 37 Hydrogen reacts with oxygen as shown in the equation below.



How much gas will remain if 2 dm³ of hydrogen are reacted with 1 dm³ of oxygen at room temperature?

- A 0 dm³
- B 1 dm³
- C 2 dm³
- D 3 dm³

- 38 The complete combustion of 20 cm³ of a gaseous alkane, Y, requires 130 cm³ of oxygen. Both volumes were measured at r.t.p..

What could be the identity of Y?

- A butane
- B methane
- C ethane
- D propane

- 39 1.0 mole of Cu₃FeS₃ and 1.0 mole of O₂ are allowed to react according to the equation.



Which of the following is true?

- A 0.286 mole of Cu₃FeS₃ is in excess
- B 0.714 mole of Cu₃FeS₃ is in excess
- C 5.0 moles of O₂ is in excess
- D no reagent is in excess

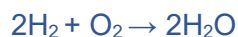
- 40 Which one of the following has the most number of atoms?

- A 10 g nitrogen gas
- B 10 g magnesium
- C 10 g oxygen gas
- D 10 g carbon dioxide

- 41 A gas contains 46.2% of carbon and 53.8% of nitrogen. Under room temperature and pressure (r.t.p.), its volume and mass are 6 dm³ and 13 g respectively. What is the molecular formula of the gas?

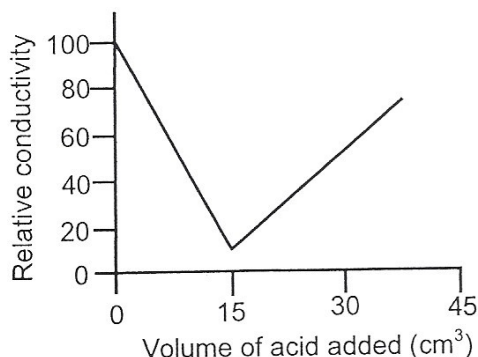
- A C₃N₂
- B C₂N₂
- C CN
- D C₃N₃

- 42 A mixture of 8.0 g of hydrogen with 8.0 g of oxygen is ignited.



What is the mass of water formed?

- A 9.0 g**
B 16.0 g
C 18.0 g
D 36.0 g
- 43 The complex ion $[\text{Ag}(\text{NH}_3)_x]^+$ consists of 76% by mass of silver. What is the value of x ?
- A 5**
B 4
C 3
D 2
- 44 The empirical formula of a liquid compound is known to be $\text{C}_2\text{H}_4\text{O}$. What other information is needed to work out its molecular formula?
- A percentage composition of the compound**
B relative molecular mass of the compound.
C density of the compound
D volume occupied by one mole of the compound
- 45 20.0 cm^3 of KOH solution was titrated with $0.200 \text{ mol dm}^{-3}$ H_2SO_4 solution in a conductivity cell. The data obtained was plotted to give the graph shown below.



What is the concentration of the KOH solution?

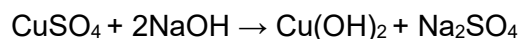
- A $0.300 \text{ mol dm}^{-3}$**
B $0.150 \text{ mol dm}^{-3}$
C $0.120 \text{ mol dm}^{-3}$
D $0.075 \text{ mol dm}^{-3}$
- 46 Which ion is present in the highest concentration in a 2 mol dm^{-3} aqueous solution of sodium sulfate?
- A hydrogen ions, $\text{H}^+(\text{aq})$**
B hydroxide ions, $\text{OH}^-(\text{aq})$
C sodium ions, $\text{Na}^+(\text{aq})$
D sulfate ions, $\text{SO}_4^{2-}(\text{aq})$

- 47 The reaction between hydrochloric acid and calcium carbonate is as shown:



What volume of 1.0 mol dm^{-3} hydrochloric acid is needed to react completely with 1.0 g of calcium carbonate ($M_r = 100$)?

- A 10 cm^3
B 20 cm^3
C 100 cm^3
D 200 cm^3
- 48 Which of the following is the correct ratio of the number of atoms in 112 g of gaseous nitrogen to the number of atoms in 90 g of ethane (C_2H_6)?
- A $1 : 1$
B $1 : 3$
C $1 : 6$
D $1 : 12$
- 49 In an experiment, 16.0 cm^3 of 1.0 mol dm^{-3} aqueous copper(II) sulfate was mixed with 8.0 cm^3 of 1.0 mol dm^{-3} of aqueous sodium hydroxide.



What did the reaction vessel contain when the reaction was complete?

- A a colourless solution
B a blue precipitate and a blue solution
C a blue precipitate and a colourless solution
D a white precipitate and a blue solution
- 50 The formula of a sodium compound in silica gel is $\text{Na}_2\text{Si}_4\text{O}_x$. What is the value of x if the relative molecular mass of the sodium compound is 302 ?
- A 8
B 9
C 10
D 12

- 51 5 g of element **X** reacted with 8 g of element **Y** to form a compound with the formula **XY₂**. Given that 80 is the relative atomic mass of **Y**, what is the relative atomic mass of **X**?
- A 25
 - B 50
 - C 40
 - D 100**
- 52 Which of the following has the largest number of atoms?
- A 0.1 mole of oxygen
 - B 0.2 mole of water**
 - C 0.3 mole of carbon
 - D 0.4 mole of helium

Paper 2 Section A

2 Aspirin tablets have important medical uses.

Aspirin ($C_9H_8O_4$) is made when salicylic acid ($C_7H_6O_3$) reacts with ethanoic anhydride. The equation for this reaction is



Calculate the **maximum** mass of aspirin that could be made from 100 g of salicylic acid.

$$\begin{aligned} \text{Mole of salicylic acid} &= \\ 100 \text{ g} / 138 &= 0.7246 \text{ mol [1] (working round off to 4sf)} \end{aligned}$$

$$\begin{aligned} \text{mass of aspirin} &= 0.7246 \text{ mol} \times 180 = 130.4 \text{ g} \\ &= 130 \text{ g (3sf) [1]} \end{aligned}$$

(b) (i) In an experiment, a chemist calculated the maximum yield of aspirin is 400 g. The chemist did the experiment but only made 250 g of aspirin. Calculate the percentage yield of aspirin for this experiment.

Show clearly how you work out your answer and suggest one possible reason why the chemist did not have a percentage yield of 100%.

$$\begin{aligned} 250 / 400 * 100 &= 62.5 \% [1] \\ - \text{ Reversible reaction / Some products are lost through other reactions /} \\ &\text{reactants are contaminated / contains impurities. [1]} \end{aligned}$$

[2]

(ii) Suggest how the use of catalyst might reduce costs in the industrial production of aspirin.

Catalyst provides an alternative pathway of lesser energy hence less energy / temperature is required, reducing the cost of production [1]

(c) Instant cold packs are used to treat sports injuries.



One type of cold pack has a plastic bag containing water. Inside the bag is a smaller bag containing solid ammonium nitrate. The outer bag is squeezed so that the inner bag bursts.

Explain why the bag becomes cold.

It is an endothermic reaction [1]

It absorbs heat energy from the surroundings / temperature mixture as the ammonium nitrate dissolves. [1]

[Total: 7]

2 In an experiment, 20.0 cm³ of 0.550 mol/dm³ of barium nitrate was added to excess aqueous sodium sulfate to produce barium sulfate and sodium nitrate.

(a) Calculate the maximum mass of barium sulfate produced.

$$\text{Number of moles} = 0.020 \times 0.550 = 0.011 \text{ mol}$$

$$\text{Mass} = 0.011 \times (137 + 32 + 16 \times 4) = 2.563 \text{ g}$$

[2]

(b) A mass of 1.92 g of dry barium sulfate was obtained.

Calculate the percentage yield of barium sulfate.

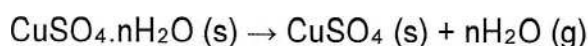
$$\text{Percentage yield} = (1.92 \div 2.563) \times 100 \% = 74.9$$

[2]

[Total: 4]

3 The formula of hydrated copper(II) sulfate is CuSO₄.nH₂O, where n is a number to be determined.

When hydrated copper(II) sulfate is heated, anhydrous copper(II) sulfate, CuSO₄, is formed and water vapour is given off according to the equation below.



2.00 g of hydrated copper(II) sulfate was heated until no further loss in mass was recorded. By the end of the reaction, the mass of the anhydrous copper(II) sulfate was.

(a) State which instrument was used to determine the mass of the solids.

.....[1]

(b) (i) Calculate the number of moles of anhydrous copper(II) sulfate formed.

.....[1]

(ii) Calculate the number of moles of water vapour released.

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

(iii) Hence, calculate the value of n.

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

(c) (i) State whether obtaining anhydrous copper(II) sulfate and water from hydrated copper(II) sulfate is a physical or chemical change. Explain your answer.

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

(ii) Suggest why a gas syringe cannot be used to collect the water vapour produced from this reaction at room temperature and pressure.

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

[Total: 7]

3	(a)	Mass balance	[1]
	(bi)	$\text{No of moles of anhydrous copper(II) sulfate} = \frac{1.28}{64 + 32 + 16 \times 4}$ $= 0.008 \text{ mol}$	[1]
	(bii)	$\text{Mass of water vapour released} = 2.00 - 1.28$ $= 0.72 \text{ g [1]}$ $\text{No of moles of water vapour released} = \frac{0.72}{1 \times 2 + 16}$ $= 0.04 \text{ mol [1]}$	[2]
	(biii)	$\text{Hence, } n = \frac{0.04}{0.008}$ $= 5 \text{ [1]}$	[1]
	(ci)	It is a chemical change because a new product has been formed OR it is a chemical change because heat was used to create a new product.	[1]
	(cii)	The water vapour would immediately condense on the cool surface of the syringe and cannot be collected as a gas.	[1]

4 2 moles of aqueous silver nitrate was mixed with 3 moles of aqueous sodium chloride. A white solid, silver chloride, was formed together with one other aqueous product.

Filtration was performed on the mixture to separate the solid and the solution.

(a) (i) Write the balanced chemical equation for this reaction.

.....[1]

(ii) Hence, write the balanced ionic equation for the same reaction. Include state symbols.

.....[2]

(b) (i) State which reactant, aqueous silver nitrate or aqueous sodium chloride, is the limiting reagent

.....[1]

(ii) Name the substances found in the filtrate after filtration had been completed. Explain your answer.

.....

 [2]

(c) Calculate the mass of silver chloride formed from the reaction.

.....
[1]

[Total : 71]

4	(ai)	$\text{AgNO}_3 + \text{NaCl} \rightarrow \text{AgCl} + \text{NaNO}_3$	[1]
	(aii)	$\text{Ag}^+ (\text{aq}) + \text{Cl}^- (\text{aq}) \rightarrow \text{AgCl} (\text{s})$ [1] - correct chemical species [1] - correct state symbols.	[2]
	(bi)	Silver nitrate	[1]
	(bii)	Sodium chloride and sodium nitrate. [1] Since sodium chloride is in excess, it would also form part of the filtrate together with sodium nitrate. [1]	[2]
	(c)	Mass of silver chloride = $2 \times (108 + 35.5)$ $= 287 \text{ g}$	[1]

- 5 A photographic plate is made up of a plastic base covered with a layer of 0.50 g silver bromide. After a photograph is taken, 35% of the silver bromide is reduced to silver. The image is then fixed by reacting the remaining silver bromide with aqueous sodium thiosulfate as shown in the equation below.



- (a) What is the mass of silver bromide remaining on the plate after a photograph is taken?

mass of silver bromide =
.....[1]

- (b) How many moles of sodium thiosulfate is needed to fix the plate?

moles of sodium thiosulfate =
.....[2]

- (c) A 100 cm³ sample of 0.200 mol/dm³ sodium thiosulfate is used in the fixing process. Calculate the number of moles of thiosulfate left after the process.

moles of sodium thiosulfate =
.....[2]

- (d) Explain using oxidation states, why the silver bromide is said to be reduced to silver.

.....

.....[1]

- (e) Silver bromide is a pale yellow insoluble halide salt. Briefly describe how a pure and dry sample of silver bromide can be prepared starting from silver nitrate.

.....

.....

.....

.....

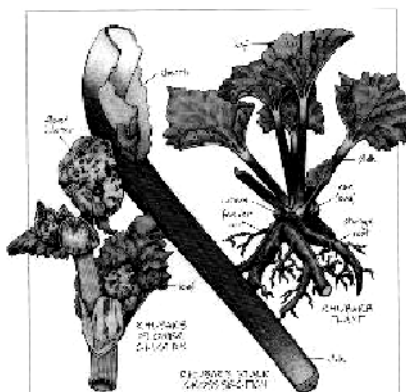
[2]

[Total: 8]

5	(a)	$6 / 100 \times 0.5 = \mathbf{0.325g}$	1	Very well-answered. Only 2 girls could not do this question. The rest of the class obtained full or close to full marks
	(b)	No. of moles of AgBr = $0.325 / (108+80) = 0.001729$ No. of moles of Na ₂ S ₂ O ₃ = $2 \times 0.001728 = \mathbf{0.00348}$	1	
	(c)	No. of moles of Na ₂ S ₂ O ₃ used = $100/1000 \times 0.2 = 0.02$ No. of moles of Na ₂ S ₂ O ₃ left = $0.02 - 0.00346 = 0.0165$	1	
	(d)	Oxidation state of silver decreases from +1 in AgBr to 0 in Ag .	1	Well-answered
	(e)	Add silver nitrate to sodium bromide (any Group I bromide) until no more precipitate forms. Filter to obtain silver bromide as the residue. Wash the residue with a little distilled water and dry it in between 2 pieces of filter papers	1	Many students cannot answer this simple preparation of salts question which is extracted from Sci (Chem). Some could not even differentiate between the filtrate and residue. A small number of students wrote "react silver nitrate with aqueous bromine"

Structured Questions

6 The picture below shows the leaf and stem of the rhubarb plant.



[Picture taken from http://northcoastcafe.typepad.com/north_coast_cafe/2004/03/rhubarb_1.html]

A team of scientists interested in studying Rhubarb discovered that rhubarb leaves contained high amounts of substance **X**. Substance **X** can be poisonous to humans.

When comparing two aqueous solutions of hydrochloric acid and substance **X** of the same concentration, it was found that hydrochloric acid has a pH of 1 and substance **X** has a pH of 3. Upon titrating substance **X** with sodium hydroxide, the scientists discovered that one mole of substance **X** reacts with two moles of sodium hydroxide.

The scientists were also interested in the colour pigments present in the Rhubarb leaf. When the leaf is crushed and mixed with the solvent propanone, the coloured pigments are extracted to give a deep green solution. One of the pigments in this solution is chlorophyll.

(a) Describe what would be observed when calcium carbonate is added to substance **X**.

[2]

Bubbles of gas (effervescence) is observed [1].

Bubbles of gas will produce white precipitate when passed through limewater [1]

(b) Substance **X** has composition 71.1% oxygen, 2.2% hydrogen and 26.7% carbon by mass. Given that the M_r of substance **X** is 90, calculate the molecular formula of substance **X**.

Assuming 100 g of **X**,

	O	H	C
Mass/g	71.1	2.2	26.7
A_r	16.0	1.0	12.0
No. of moles	$71.1/16.0 = 4.444$	$2.2/1.0 = 2.2$	$26.7/12.0 = 2.225$
Simplest ratio	2	1	1

Empirical formula is CHO_2 . [1]

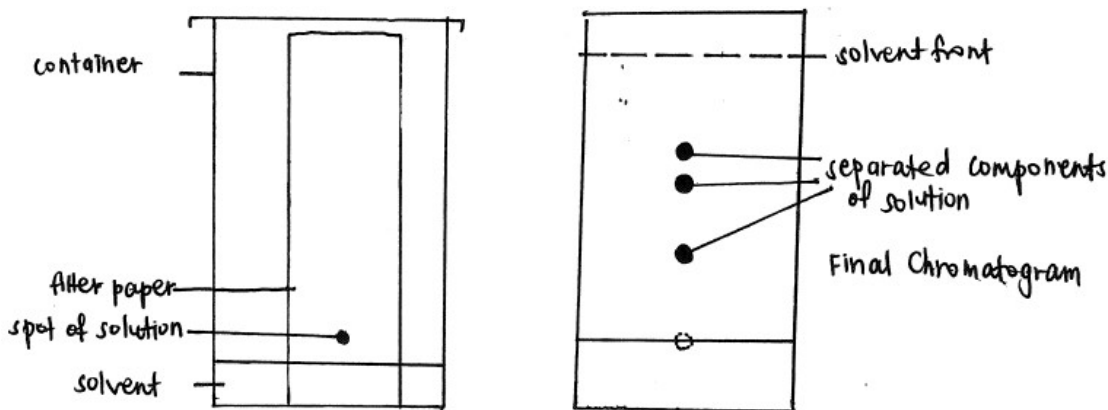
$$M_r(\text{CHO}_2) = 45$$

$$M_r(\text{CHO}_2)_n = 90 \quad n = 90/45 = 2$$

Molecular formula is $(\text{CHO}_2)_2 = \text{C}_2\text{H}_2\text{O}_4$ [1]

(c) How would you show that chlorophyll is not the only pigment in the solution? Name and describe the technique used and explain the expected results.

Use diagrams to illustrate your answer. [4]



Paper chromatography [1]. A small spot of the solution is spotted on a piece of filter paper which is placed in a covered container containing a suitable solvent below the start line of the spot. The solvent is allowed to rise up the filter paper and **the pigment(s) in the solution will rise up the filter paper according to how soluble they are** (the more soluble, the higher up it moves) [1]. If 2 or more spots are observed, there is more than 1 pigment and not just chlorophyll [1].

- 7 (a) Antacid tablets are ingested to provide relief for gastric pains. Antacid tablets containing magnesium carbonate are seldom used nowadays. Instead, magnesium hydroxide is usually used as the active ingredient. Based on the reactions involved, suggest one reason why magnesium hydroxide is preferred to magnesium carbonate. [1]

Magnesium carbonate reacts with hydrochloric acid to produce carbon dioxide gas which can cause discomfort but not magnesium hydroxide [1].



- (b) Irene took some tablets containing magnesium hydroxide to relieve stomach pains caused by excess hydrochloric acid present in the gastric juice.

- (i) Write a chemical equation for the above reaction. [1]



- (ii) Gastric juice in the stomach contains the equivalent of 100 cm³ of hydrochloric acid of concentration 2.00 mol dm⁻³. If one tablet contains 3.00 g of magnesium hydroxide, calculate the minimum number of tablets required to relieve the stomach pains. [3]

$$\begin{aligned} \text{No. of moles of HCl} &= 2.00 \times \frac{100}{1000} \\ &= 0.20000 \text{ mol} \end{aligned}$$

From the equation, 1 mol Mg(OH)₂ is required to neutralise 2 mol HCl

$$\text{No. of moles of Mg(OH)}_2 \text{ required} = \frac{0.2000}{2} = 0.10000 \text{ mol} \quad [1]$$

$$\begin{aligned} \text{No. of moles of Mg(OH)}_2 \text{ in 1 tablet} &= \frac{3}{24.3 + 16.0 \times 2 + 1.0 \times 2} \\ &= \frac{3}{58.3} \\ &= 0.051458 \text{ mol} \quad [1] \end{aligned}$$

$$\begin{aligned} \text{No. of tablets required} &= \frac{0.10000}{0.051458} \\ &= 1.94 \\ &= 2 \quad [1] \end{aligned}$$

- 8 The following experiment was conducted by the Consumer Association of Singapore to compare the composition of two commercial brands of vinegar.

25.0 cm³ of Brand X vinegar was titrated against 1.00 mol dm⁻³ NaOH solution, using phenolphthalein as an indicator. The equation for neutralisation is as shown below:



The volume of NaOH required for titration was found to be 26.25 cm³.

- (a) Describe the colour change of the indicator at the end point. [1]

colourless to faint pink [1]

- (b) (i) Calculate the concentration of ethanoic acid, CH₃COOH present in Brand X vinegar in mol dm⁻³. [2]

$$\text{No. of moles of NaOH} = 1.00 \times \frac{26.25}{1000}$$

$$= 0.026250 \text{ mol}$$

From the equation, 1 mol NaOH reacts with 1 mol CH₃COOH

$$\text{No. of moles of CH}_3\text{COOH} = 0.026250 \text{ mol [1]}$$

$$\text{Concentration of CH}_3\text{COOH} = \frac{0.026250}{\frac{25.0}{1000}}$$

$$= 1.05 \text{ mol dm}^{-3} \text{ [1]}$$

- (ii) Given that the density of Brand X vinegar is 1.05 g cm^{-3} , calculate the percentage by mass of ethanoic acid, CH_3COOH in the vinegar. [2]

$$\text{Mass of Brand X vinegar} = 1.05 \times 25.0$$

$$= 26.25 \text{ g}$$

$$\text{Mass of } \text{CH}_3\text{COOH} \text{ in Brand X vinegar}$$

$$= 1.05 \times \frac{25.0}{1000} \times (12.0 \times 2 + 1.0 \times 4 + 16.0 \times 2)$$

$$= 1.575 \text{ g [1]}$$

$$\% \text{ by mass of } \text{CH}_3\text{COOH} \text{ in the vinegar} = \frac{1.575}{26.25}$$

$$= 6.00 \% \text{ [1]}$$

- (c) The prices of Brand X and Brand Y vinegar are given below:

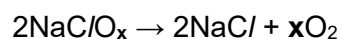
brand	price per bottle	volume of vinegar in 1 bottle (cm ³)	concentration of ethanoic acid (mol dm ⁻³)
X	\$4.	125	-
Y	\$8.	250	0.833

Using your answer in (b), explain which brand of vinegar will be a better buy. [2]

Brand X [1]. Concentration of CH_3COOH is higher and hence the CH_3COOH per unit volume cost of X is lower [1].

9 Sodium forms 2 compounds with chlorine and oxygen.

- (a) One mole of NaClO_x decomposes at room temperature³ to produce 36 dm³ of oxygen (one of the compounds) according to the equation below.



What is the formula of this compound? (Show all the essential working) [3]

$$\begin{aligned}\text{No. of moles of O}_2 \text{ produced} &= \frac{36}{24} \\ &= 1.50 \text{ mol [1]}\end{aligned}$$

1 mol of NaC/O_x produces 1.5 mol of O_2 , hence 2 mol of NaC/O_x produces 3 mol of O_2 .

$$\begin{aligned}\text{No. of moles of O} &= 3 \times 2 \\ &= 6 \text{ mol [1]}\end{aligned}$$

Therefore, formula of the compound is NaC/O_3 [1].

(b) One mole of NaC/O_y (the other compound) reacts with 73.0 g of dilute hydrochloric acid to form 58.5 g of sodium chloride, 18 g of water and 24 dm^3 of chlorine at room temperature and pressure.

(i) Calculate the number of moles of hydrochloric acid reacted and sodium chloride, water and chlorine formed. [1]

$$\begin{aligned}\text{No. of moles of HCl reacted} &= \frac{73.0}{1.0 + 35.5} \\ &= 2.00 \text{ mol}\end{aligned}$$

$$\begin{aligned}\text{No. of moles of NaCl formed} &= \frac{58.5}{23.0 + 35.5} \\ &= 1.00 \text{ mol}\end{aligned}$$

$$\begin{aligned}\text{No. of moles of H}_2\text{O formed} &= \frac{18.0}{1.0 \times 2 + 16.0} \\ &= 1.00 \text{ mol}\end{aligned}$$

$$\begin{aligned}\text{No. of moles of Cl}_2 \text{ formed} &= \frac{24}{24} \\ &= 1.00 \text{ mol}\end{aligned}$$

- (i) Give the chemical equation for the reaction for NaClO_y . [1]



- (iii) Hence, give the formula of this compound. [1]



- 10 In an experiment, 2.76 g of sodium react with an excess amount of gaseous element **E**. At the end of the experiment, 12.36 g of compound NaE is obtained.

- (a) Calculate the mass of gas **E** reacted with sodium. [1]

By law of conservation of mass,

$$\text{Mass of gas E} = 12.36 - 2.76 = 9.60 \text{ g}$$

- (b) Determine the relative atomic mass of element **E**. [3]



Na is the limiting reagent.

$$\begin{aligned} \text{No. of moles of Na} &= \frac{2.76}{23.0} \\ &= 0.120 \text{ mol [1]} \end{aligned}$$

From the equation, 1 mol Na reacts with 1 mol E

$$\text{No. of moles of E} = 0.120 \text{ mol [1]}$$

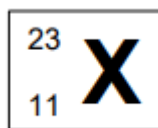
0.120 mol E has a mass of 9.60 g

$$A_r(\text{E}) = \frac{9.60}{0.120} = 80 \text{ [1]}$$

- (c) Identify element **E**. [1]

Bromine, Br (from Periodic Table)

11 The diagram below shows the symbol of the atom of element **X**.



- (a) **X** forms a compound with sulfur and oxygen. 12.34 g of this compound contains 5.00 g of sulfur and 3.75 g of oxygen. If the molar mass of the compound is 158 g mol⁻¹. What is the molecular formula of the compound? [4]

	S	O	X
Mass/g	5.00	3.75	12.34 – 5.00 – 3.75 = 3.59
A _r	32.1	16.0	23.0
No. of moles	5.00/32.1 = 0.1557	3.75/16.0 = 0.2344	3.59/23.0 = 0.1561
Simplest ratio	1.000 × 2 = 2	1.505 × 2 = 3	1.003 × 2 = 2

Empirical formula is S₂O₃X₂. [1]

$$M_r(\text{S}_2\text{O}_3\text{X}_2) = 32.1 \times 2 + 16.0 \times 3 + 23.0 \times 2 = 158.2$$

$$M_r(\text{S}_2\text{O}_3\text{X}_2)_n = 158$$

$$n = 158/158.2 \approx 1$$

Molecular formula is (S₂O₃X₂)₁ = S₂O₃X₂ [1]

- (b) An aqueous solution of this compound reacts with aqueous hydrochloric acid to form an aqueous solution of chloride of **X**, sulfur, sulfur dioxide and water.

- (i) Write the chemical equation including the state symbols for this reaction. [1]



- (ii) Calculate the maximum mass of sulfur deposited when 4 g of the compound is added to 0.0400 mole aqueous hydrochloric acid.

[3]

$$\text{No. of moles of compound} = \frac{4}{32.1 \times 2 + 16.0 \times 3 + 23.0 \times 2}$$

$$= 0.025284 \text{ mol}$$

Mole ratio of compound to hydrochloric acid

$$= 0.025284 : 0.04000$$

$$= 1 : 1.58$$

From the equation, 1 mol $\text{S}_2\text{O}_3\text{X}_2$ reacts with 2 mol HCl.
HCl is the limiting reactant [1].

From the equation, 2 mol HCl forms 1 mol S

$$\text{No. of moles of S} = \frac{0.0400}{2}$$

$$= 0.0200 \text{ mol [1]}$$

$$\text{Maximum mass of S} = 0.0200 \times 32.1 = 0.642 \text{ g [1]}$$

12 In an experiment, a sample of iron powder was oxidized to form a certain oxide of iron.

- (a) Calculate the empirical formula of the oxide if it contained 30% by mass of oxygen.

[3]

Assuming 100 g of the oxide,

	Fe	O	
Mass/g	70	30	
A_r	55.9	16.0	
No. of moles	$70/55.9 = 1.252$	$30/16.0 = 1.875$	[1]
Simplest ratio	$1 \times 2 = 2$	$1.498 \times 2 = 3$ (whole no.)	[1]

Empirical formula of oxide = Fe_2O_3 [1]

(b) 0.5 mol of the oxide of iron produced in (a) completely reacted with 109.5 g of dilute hydrochloric acid to form a salt of iron and water.

- (i) Calculate the number of moles of hydrochloric acid reacted. [2]

$$\begin{aligned}\text{No. of moles of HCl} &= \underline{109.5} \text{ [1]} \\ &= \frac{109.5}{35.5} \\ &= 3.00 \text{ mol [1]}\end{aligned}$$

- (iv) Write down a balanced chemical equation for this reaction, complete with the state symbols. [2]

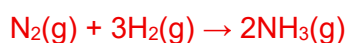


- (v) Describe the observations that will be obtained when excess aqueous sodium hydroxide was added gradually to the salt of iron obtained from the reaction. [2]

As a few drops of NaOH(aq) was added, a reddish-brown precipitate is observed in a yellow solution [1], which is insoluble in excess NaOH(aq) [1].

- 13 (a) When nitrogen gas was reacted with hydrogen gas at a certain temperature and pressure, ammonia gas was produced. If there were 120 dm³ (measured at r.t.p.) of ammonia gas produced,

- (i) determine the mass of ammonia gas produced. [1]



$$\begin{aligned}\text{No. of moles of NH}_3 \text{ produced} &= \frac{120}{24} \\ &= 5.0000 \text{ mol}\end{aligned}$$

$$\begin{aligned}\text{Mass of NH}_3 \text{ produced} &= 5.0000 \times (14.0 + 1.0 \times 3) \\ &= \mathbf{85.0 \text{ g}}\end{aligned}$$

- (ii) calculate the mass of nitrogen present in the ammonia gas produced. [1]

$$\begin{aligned}\text{Mass of N} &= 14.0 \times 85.0 \\ &= 17.0 \\ &= 70.0 \text{ g}\end{aligned}$$

- (iii) calculate the number of ammonia molecules produced. [1]

$$\begin{aligned}\text{No. of NH}_3 \text{ molecules produced} &= 5.0000 \times 6.02 \times 10^{23} \\ &= 3.01 \times 10^{24} \text{ mol}\end{aligned}$$

- (b) The empirical formula of a certain gas is XY_2 .

The relative atomic mass of **X** and **Y** are 12 and 1 respectively.

- (i) If the relative molecular mass of the gas is 42, determine the molecular formula of the gas. [1]

$$M_r(\text{XY}_2) = 12.0 + 1.0 \times 2 = 14.0$$

$$\begin{aligned}n &= \frac{42.0}{14.0} \\ &= 3\end{aligned}$$

$$\text{Molecular formula of gas} = (\text{XY}_2)_3 = \text{X}_3\text{Y}_6$$

- (ii) A sealed cylinder contains 36 dm³ (measured at r.t.p) of the gas mentioned in (b)(i).

Calculate the mass of Y present in the gas. [2]

$$\text{No. of moles of gas} = \frac{36}{24} = 1.5 \text{ mol}$$

$$\begin{aligned}\text{Mass of gas} &= 1.50 \times (12.0 \times 3 + 1.0 \times 6) \\ &= 63.0 \text{ g [1]}\end{aligned}$$

$$\begin{aligned}\text{Mass of Y in the gas} &= \frac{6.0}{63.0} \times 63.0 \\ &= 9.00 \text{ g [1]}\end{aligned}$$

- 14 When excess aqueous sodium hydroxide is added gradually to an aqueous solution X, a dirty green precipitate which is insoluble in excess aqueous sodium hydroxide is formed. The reaction also forms aqueous chloride Y.

- (a) State the chemical name of aqueous solution X and Y respectively. [2]

X: iron(II) chloride [1]

Y: sodium chloride [1]

- (b) For every mole of X reacted, 2 moles of Y are formed. Calculate the mass of X reacted if 11.7g of Y is produced. [3]

$$\text{No. of moles of Y produced} = \frac{11.7}{23.0 + 35.5}$$

$$= 0.20000 \text{ mol [1]}$$

$$\text{No. of moles of X reacted} = \frac{20000}{2.0}$$

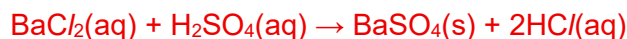
$$= 0.10000 \text{ mol [1]}$$

$$\text{Mass of X reacted} = 0.10000 \times (55.9 + 35.5 \times 2)$$

$$= 12.69$$

$$= 12.7 \text{ g [1]}$$

- 15 (a) In an experiment, 25.0 cm³ of 1.0 mol dm⁻³ of barium chloride solution is added to 100 cm³ of 1.0 mol dm⁻³ of sulfuric acid.
- (i) Write the balanced chemical equation, including the state symbols, for the reaction between barium chloride and sulfuric acid. [1]



- (ii) Show by calculation which substance acts as a limiting reagent. [3]

$$\begin{aligned}\text{No. of moles of BaCl}_2 &= 1.00 \times \frac{25.0}{1000} \\ &= 0.025000 \text{ mol [1]}\end{aligned}$$

$$\begin{aligned}\text{No. of moles of H}_2\text{SO}_4 &= 1.00 \times \frac{100}{1000} \\ &= 0.10000 \text{ mol [1]}\end{aligned}$$

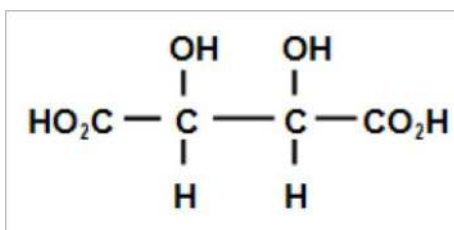
From the equation, 1 mol of BaCl₂ reacts with 1 mol H₂SO₄, hence BaCl₂ is the limiting reactant [1].

- (iii) Describe briefly how to make pure and dry sodium nitrate crystals in the school laboratory. [4]

Titrate NaOH solution with HNO₃ solution with a suitable indicator (e.g. methyl orange) [1] to indicate end-point so that there is no excess NaOH or HNO₃.

Repeat the titration using the volume of NaOH added at end-point [1].
Heat the solution to obtain a saturated solution, cool the saturated solution and filter to obtain NaNO₃ crystals [1]. Wash the crystals with cold distilled water and dry between sheets of filter paper to obtain pure and dry NaNO₃ crystals [1].

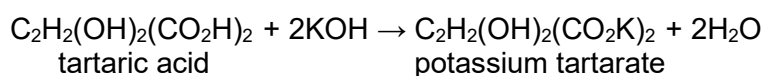
- 16 Tartaric acid is a weak dibasic organic acid that can be extracted from grape juice. It is purified by recrystallization. The structure of tartaric acid is shown below.



- (a) (i) Define weak acid

A weak acid is an acid that ionises partially in water to produce H^+ ions.

- (b) Tartaric acid reacts with aqueous potassium hydroxide according to the equation shown below.



A test analysis showed that 11.3 g of potassium tartarate was formed when 9.0 g of impure tartaric acid were used. Calculate the percentage purity of tartaric acid.

$$\begin{aligned}
 \text{No. of moles of potassium tartarate} &= \frac{11.3}{12.0 \times 4 + 1.0 \times 6 + 16.0 \times 6 + 39.1 \times 2} \\
 &= \frac{11.3}{226.2}
 \end{aligned}$$

$$= 0.049956 \text{ mol}$$

From the equation, 1 mol tartaric acid forms 1 mol potassium tartarate.

$$\text{No. of moles of tartaric acid} = 0.049956 \text{ mol [1]}$$

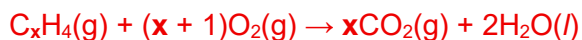
$$\text{Mass of tartaric acid} = 0.049956 \times (12.0 \times 4 + 1.0 \times 6 + 16.0 \times 6)$$

$$= 7.4934 \text{ g [1]}$$

$$\% \text{ purity of tartaric acid} = \frac{7.4934}{9.0} \times 100$$

$$= 83.3\% \text{ [1]}$$

- (b) All hydrocarbons undergo complete combustion to form carbon dioxide and water only. A 20.0 cm³ sample of a hydrocarbon of formula C_xH₄ required 60.0 cm³ of oxygen for complete combustion. If both volumes are measured at r.t.p., what is the value of x [2]



$$\text{Mole ratio of C}_x\text{H}_4 \text{ to O}_2 = 20 : 60 = 1 : 3$$

From the equation, 1 mol C_xH₄ reacts with (x + 1) mol O₂ [1].

$$x+1=3$$

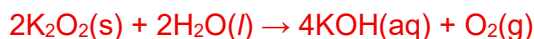
$$x=2 \text{ [1]}$$

- 17 When potassium is burnt in oxygen, it forms potassium peroxide (K₂O₂).

In spaceships, potassium peroxide is dissolved in water to form potassium hydroxide and oxygen. Potassium hydroxide removes carbon dioxide while oxygen is required for breathing.

In a particular spaceship, 13.2 g of potassium peroxide is dissolved in 0.500 dm³ of water.

- (c) Write the balanced chemical equation for the reaction between potassium peroxide and water. [1]



- (d) Calculate the number of moles of potassium hydroxide. [2]

$$\text{No. of moles of K}_2\text{O}_2 = 39.1 \times 2 + 16.0 \times 2$$

$$= 0.11978 \text{ mol [1]}$$

From the equation, 2 mol K₂O₂ forms 4 mol KOH.

$$\begin{aligned} \text{No. of moles of KOH} &= 0.11978 \times 2 \\ &= 0.23956 \\ &= 0.240 \text{ mol [1]} \end{aligned}$$

(c) Calculate the mass of oxygen gas produced.

[1]

From the equation, 2 mol K_2O_2 forms 1 mol O_2

$$\text{No. of moles of } O_2 = \frac{0.11978}{2}$$

$$= 0.05989 \text{ mol}$$

$$\text{Mass of } O_2 = 0.05989 \times (16.0 \times 2)$$

$$= 1.9165$$

$$= 1.92 \text{ g}$$

(d) Calculate the volume of oxygen gas produced when the gas is cooled to room temperature and pressure.

[1]

$$\text{Volume of } O_2 = 0.05989 \times 24$$

$$= 1.4374$$

$$= 1.44 \text{ dm}^3$$