**AS LEVEL CHEMISTRY**

**TOPIC 2 – AMOUNT OF SUBSTANCE**

**ASSESSED HOMEWORK**

Answer all questions

Max 80 marks

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|  | Name …………………………………………………………….. |  |
|  | Mark ……../80 ……....% Grade ……… |  |

**1.** Hydrogen peroxide is sold commercially as an aqueous solution containing approximately 60 g dm–3 of hydrogen peroxide.

(a)     Use data from the Periodic Table to calculate the *M*r of hydrogen peroxide. Give your answer to the appropriate precision.

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(b)     Calculate the concentration, in mol dm–3, of a solution containing 60.0 g dm–3 of hydrogen peroxide.

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(c)     The concentration of hydrogen peroxide in a hair bleach is 0.050 mol dm–3. Use your answer from (b) to calculate the dilution factor needed to make the commercial hydrogen peroxide solution suitable for use in this hair bleach. Show your working.

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**(2)**

**(Total 4 marks)**

**2.** A chemist was asked to prepare a standard solution of sodium carbonate.   
The chemist dissolved an accurately known mass of sodium carbonate in a small amount of water in a conical flask. The chemist then poured the solution into a 250 cm3 graduated flask and made the solution up to the mark. Suggest **one** improvement to the chemist’s procedure.

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**(Total 1 mark)**

**3.** Zinc forms many different salts including zinc sulfate, zinc chloride and zinc fluoride.

(a)     People who have a zinc deficiency can take hydrated zinc sulfate (ZnSO4.*x*H2O) as a dietary supplement.

A student heated 4.38 g of hydrated zinc sulfate and obtained 2.46 g of anhydrous zinc sulfate.

Use these data to calculate the value of the integer *x* in ZnSO4.*x*H2O   
Show your working.

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(b)     Zinc chloride can be prepared in the laboratory by the reaction between zinc oxide and hydrochloric acid.  
The equation for the reaction is

ZnO + 2HCl   ZnCl2 + H2O

A 0.0830 mol sample of pure zinc oxide was added to 100 cm3 of 1.20 mol dm−3 hydrochloric acid.

Calculate the maximum mass of anhydrous zinc chloride that could be obtained from the products of this reaction.

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(c)     Zinc chloride can also be prepared in the laboratory by the reaction between zinc and hydrogen chloride gas.

Zn + 2HCl   ZnCl2 + H2

An impure sample of zinc powder with a mass of 5.68 g was reacted with hydrogen chloride gas until the reaction was complete. The zinc chloride produced had a mass of 10.7 g.

Calculate the percentage purity of the zinc metal.  
Give your answer to 3 significant figures.

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**(Total 11 marks)**

**4.** In a titration, it is important to wash the inside of the titration flask with distilled or deionised water as you approach the end-point.

(a)     Suggest **one** reason why it is important to wash the inside of the flask.

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(b)     Washing with water decreases the concentration of the reagents in the titration flask.

Suggest why washing with water does **not** affect the titre value.

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**(Total 2 marks)**

**5.** Read the following instructions that describe how to make up a standard solution of a solid in a volumetric flask.   
Answer the questions which follow.

‘Take a clean 250 cm3 volumetric flask. Use the balance provided and a clean, dry container, to weigh out the amount of solid required. Tip the solid into a clean, dry 250 cm3 beaker and add about 100 cm3 of distilled water. Use a stirring rod to help the solid dissolve, carefully breaking up any lumps of solid with the rod. When the solid has dissolved, pour the solution into the flask using a filter funnel. Add water to the flask until the level rises to the graduation mark.’

(a)     Suggest **three** further instructions that would improve the overall technique in this account.

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(b)     In a series of titrations using the solution made up in part (a), a student obtained the following titres (all in cm3).

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| --- | --- | --- | --- |
|  | **Rough** | **1** | **2** |
|  | 25.7 | 25.20 | 25.35 |

State what this student must do in order to obtain an accurate average titre in this experiment.

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**(2)**

**(Total 5 marks)**

**6.** Sodium hydroxide is often sold as a concentrated solution containing 12.0 mol dm–3 of sodium hydroxide.

Calculate the volume of water that should be added to 10.0 cm3 of a 12.0 mol dm–3 solution of sodium hydroxide to make a 0.250 mol dm–3 solution. Show your working.

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**(Total 2 marks)**

**7.** Ammonia is used to make nitric acid (HNO3) by the Ostwald Process.  
Three reactions occur in this process.

Reaction **1** 4NH3(g) + 5O2(g)    4NO(g) + 6H2O(g)

Reaction **2**2NO(g) + O2(g)    2NO2(g)

Reaction **3** 3NO2(g) + H2O(I)    2HNO3(aq) + NO(g)

(a)     In one production run, the gases formed in Reaction **1** occupied a total volume of 4.31 m3 at 25 °C and 100 kPa.

Calculate the amount, in moles, of NO produced.  
Give your answer to 3 significant figures.  
(The gas constant *R* = 8.31 J K−1 mol−1)

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(b)     In another production run, 3.00 kg of ammonia gas were used in Reaction **1** and all of the NO gas produced was used to make NO2 gas in Reaction **2**.

(i)      Calculate the amount, in moles, of ammonia in 3.00 kg.

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(ii)     Calculate the mass of NO2 formed from 3.00 kg of ammonia in Reaction **2** assuming an 80.0% yield.  
Give your answer in kilograms.  
(If you have been unable to calculate an answer for part (b)(i), you may assume a value of 163 mol. This is **not** the correct answer.)

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(c)     Consider Reaction **3** in this process.

3NO2(g) + H2O(I)   2HNO3(aq) + NO(g)

Calculate the concentration of nitric acid produced when 0.543 mol of NO2 is reacted with water and the solution is made up to 250 cm3.

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**(Total 11 marks)**

**8.** (a)     Calcium phosphate reacts with aqueous nitric acid to produce phosphoric acid and

calcium nitrate as shown in the equation.

Ca3(PO4)2    +    6HNO3    2H3PO4    +    3Ca(NO3)2

(i)      A 7.26 g sample of calcium phosphate reacted completely when added to an excess of aqueous nitric acid to form 38.0 cm3 of solution.

Calculate the concentration, in mol dm–3, of phosphoric acid in this solution.  
Give your answer to 3 significant figures.

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(ii)     Calculate the percentage atom economy for the formation of calcium nitrate in this reaction.  
Give your answer to 1 decimal place.

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(b)     Write an equation to show the reaction between calcium hydroxide and phosphoric acid to produce calcium phosphate and water.

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(c)     Calcium dihydrogenphosphate can be represented by the formula Ca(H2PO4)*x* where *x* is an integer.  
A 9.76 g sample of calcium dihydrogenphosphate contains 0.17 g of hydrogen, 2.59 g of phosphorus and 5.33 g of oxygen.

Calculate the empirical formula and hence the value of *x*.  
Show your working.

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**(Total 12 marks)**

**9.**          (a)     An unknown metal carbonate reacts with hydrochloric acid according to the following

equation.

M2CO3(aq) + 2HCl(aq) → 2MCl(aq) + CO2(g) + H2O(l)

A 3.44 g sample of M2CO3 was dissolved in distilled water to make 250 cm3 of solution. A 25.0 cm3 portion of this solution required 33.2 cm3 of 0.150 mol dm–3 hydrochloric acid for complete reaction.

(i)      Calculate the amount, in moles, of HCl in 33.2 cm3 of 0.150 mol dm–3 hydrochloric acid. Give your answer to 3 significant figures.

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(ii)     Calculate the amount, in moles, of M2CO3 that reacted with this amount of HCl.  
Give your answer to 3 significant figures.

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(iii)     Calculate the amount, in moles, of M2CO3 in the 3.44 g sample. Give your answer to 3 significant figures.

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(iv)    Calculate the relative formula mass, *M*r, of M2CO3 Give your answer to 1 decimal place.

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(v)     Hence determine the relative atomic mass, *A*r, of the metal M and deduce its identity.

*A*r of M .................................................................................................

Identity of M ........................................................................................

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(b)     In another experiment, 0.658 mol of CO2 was produced. This gas occupied a volume of 0.0220 m3 at a pressure of 100 kPa.  
Calculate the temperature of this CO2 and state the units.  
(The gas constant *R* = 8.31 J K–1 mol–1)

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(c)     Suggest **one** possible danger when a metal carbonate is reacted with an acid in a sealed flask.

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(d)     In a different experiment, 6.27 g of magnesium carbonate were added to an excess of sulfuric acid. The following reaction occurred.

MgCO3 + H2SO4 →  MgSO4 + CO2 + H2O

(i)      Calculate the amount, in moles, of MgCO3 in 6.27 g of magnesium carbonate.

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(ii)     Calculate the mass of MgSO4 produced in this reaction assuming a 95% yield.

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**(Total 15 marks)**

**10.** The metal lead reacts with warm dilute nitric acid to produce lead(II) nitrate, nitrogen monoxide and water according to the following equation.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 3Pb(s) | + | 8HNO3(aq) |  | 3Pb(NO3)2(aq) | + | 2NO(g) | + | 4H2O(I) |

(a)     In an experiment, an 8.14 g sample of lead reacted completely with a 2.00 mol dm-3 solution of nitric acid.

Calculate the volume, in dm3, of nitric acid required for complete reaction.  
Give your answer to 3 significant figures

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(b)     In a second experiment, the nitrogen monoxide gas produced in the reaction occupied 638 cm3 at 101 kPa and 298 K.  
Calculate the amount, in moles, of NO gas produced.  
(The gas constant *R* = 8.31 J K-1 mol-1)

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(c)     When lead(II) nitrate is heated it decomposes to form lead(II) oxide, nitrogen dioxide and oxygen.

(i)      Balance the following equation that shows this thermal decomposition.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | ........Pb(NO3)2(s) |  | ....... PbO(s) | + | .......NO2(g) | + | .......O2(g) |

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(ii)     Suggest **one** reason why the yield of nitrogen dioxide formed during this reaction is often less than expected.

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(iii)     Suggest **one** reason why it is difficult to obtain a pure sample of nitrogen dioxide from this reaction.

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**(Total 9 marks)**

**11.** A brand of fluoride tablets, recommended by a dentist to strengthen the enamel on teeth, contains

2.2 × 10−3 sodium fluoride per tablet. The total mass of fluoride ion present in 100 tablets is

**A**       2.2 × 10−3 ×  × 100

**B**       2.2 × 10−3 ×  × 100

**C**       2.2 × 10−3 ×  × 100

**D**       

**(Total 1 mark)**

**12.** When TiCI4 is reduced with hydrogen under certain conditions, a new compound is produced which contains 68.9% chlorine by mass. Which one of the following could be the formula of the new compound?

**A**       TiH2Cl2

**B**       TiCl

**C**       TiCl2

**D**       TiCl3

**(Total 1 mark)**

**13.** Which one of the following samples of gas, when sealed into a vessel of volume 0.10 m3, is at the highest pressure?

**A**       1.6 g of helium (He) at 100 K

**B**       1.6 g of methane (CH4) at 100 K

**C**       1.6 g of oxygen (O2) at 600 K

**D**       1.6 g of sulphur dioxide (SO2) at 1200 K

**(Total 1 mark)**

**14.** Which one of the following compounds contains the smallest percentage, by mass, of oxygen?

**A**       CH3OCH2CH3

**B**       CH3OCH2NH2

**C**       COS

**D**       C4H9Al(OH)2

**(Total 1 mark)**

**15.** Which one of the following contains the smallest number of moles of carbon dioxide gas?

**A**       2.65 g

**B**       0.0150 m3 at 1000 K and 33.0 kPa

**C**       1.50 dm3 at 327 °C and 200 kPa

**D**       1500 cm3 at 300 K and 100 kPa

**(Total 1 mark)**

**16.** Use the information below to answer this question.

A saturated solution of magnesium hydroxide, Mg(OH)2, contains 0.1166 g of Mg(OH)2 in 10.00 dm3 of solution. In this solution the magnesium hydroxide is fully dissociated into ions.

Which one of the following is the concentration of Mg2+(aq) ions in the saturated solution?

**A**       2.82 × 10−2 mol dm−3

**B**       2.00 × 10−3 mol dm−3

**C**       2.82 × 10−3 mol dm−3

**D**       2.00 × 10−4 mol dm−3

**(Total 1 mark)**

**17.** A particular sample of iron ore contains 85% by mass of Fe2O3 (*M*r= 159.6) and no other iron compound. The maximum mass of iron that could be extracted from 1.0 tonne of this ore is

**A**       0.59 tonne

**B**       0.66 tonne

**C**       0.75 tonne

**C**       0.85 tonne

**(Total 1 mark)**

**18.** Sodium hydrogencarbonate decomposes on heating as shown by the equation below.

2NaHCO3 → Na2CO3 + H2O + CO2

The volume of carbon dioxide, measured at 298 K and 101 kPa, obtained by heating 0.0500 mol of sodium hydrogencarbonate is

**A**       613 cm3

**B**       1226 cm3

**C**       613 dm3

**D**       1226 dm3

**(Total 1 mark)**