MEGA LECTURE

AS LEVEL CHEMISTRY

TOPIC 2 – AMOUNT OF SUBSTANCE

ASSESSED HOMEWORK

Answer all questions

Max 80 marks

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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   (1)

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

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   (1)

   (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 cm^3 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 ($ZnSO_4.xH_2O$) 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 $ZnSO_4.xH_2O$
Show your working.

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(3)

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

$$ZnO + 2HCl \longrightarrow ZnCl_2 + H_2O$$

A 0.0830 mol sample of pure zinc oxide was added to 100 cm^3 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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(4)

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

$$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$$

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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(4)
(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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(1)

(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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(1)
(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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(3)

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

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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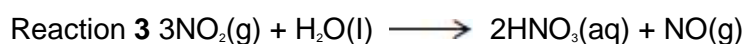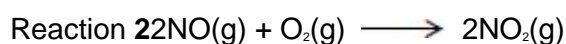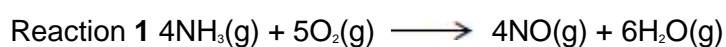
(2)
(Total 5 marks)

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 cm^3 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 (HNO$_3$) by the Ostwald Process.
    Three reactions occur in this process.

    Reaction **1** $4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$

    Reaction **2** $2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$

    Reaction **3** $3NO_2(g) + H_2O(l) \longrightarrow 2HNO_3(aq) + NO(g)$

    (a) In one production run, the gases formed in Reaction **1** occupied a total volume of 4.31 m^3 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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         (4)

    (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 NO$_2$ gas in Reaction **2**.

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

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              (2)

(ii)   Calculate the mass of NO_2 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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(3)

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

$$3NO_2(g) + H_2O(l) \longrightarrow 2HNO_3(aq) + NO(g)$$

Calculate the concentration of nitric acid produced when 0.543 mol of NO_2 is reacted with water and the solution is made up to 250 cm^3.

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(2)
(Total 11 marks)

8. (a) Calcium phosphate reacts with aqueous nitric acid to produce phosphoric acid and calcium nitrate as shown in the equation.

$$Ca_3(PO_4)_2 \ + \ 6HNO_3 \longrightarrow 2H_3PO_4 \ + \ 3Ca(NO_3)_2$$

(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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(2)

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

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(1)

(c) Calcium dihydrogenphosphate can be represented by the formula $Ca(H_2PO_4)_x$ 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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(4)
(Total 12 marks)

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

$$M_2CO_3(aq) + 2HCl(aq) \quad 2MCl(aq) + CO_2(g) + H_2O(l)$$

A 3.44 g sample of M_2CO_3 was dissolved in distilled water to make 250 cm^3 of solution. A 25.0 cm^3 portion of this solution required 33.2 cm^3 of 0.150 mol dm^{-3} hydrochloric acid for complete reaction.

   (i)   Calculate the amount, in moles, of HCl in 33.2 cm^3 of 0.150 mol dm^{-3} hydrochloric acid. Give your answer to 3 significant figures.

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(1)

   (ii)   Calculate the amount, in moles, of M_2CO_3 that reacted with this amount of HCl. Give your answer to 3 significant figures.

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(1)

   (iii)   Calculate the amount, in moles, of M_2CO_3 in the 3.44 g sample. Give your answer to 3 significant figures.

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(1)

   (iv)   Calculate the relative formula mass, M_r, of M_2CO_3 Give your answer to 1 decimal place.

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(1)

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

A_r of M ....

Identity of M ....

(2)

(b)   In another experiment, 0.658 mol of CO_2 was produced. This gas occupied a volume of 0.0220 m^3 at a pressure of 100 kPa.
Calculate the temperature of this CO_2 and state the units.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

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(3)

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

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(1)

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

$$MgCO_3 + H_2SO_4 \quad MgSO_4 + CO_2 + H_2O$$

(i)   Calculate the amount, in moles, of $MgCO_3$ in 6.27 g of magnesium carbonate.

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(2)

(ii)   Calculate the mass of $MgSO_4$ produced in this reaction assuming a 95% yield.

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(3)
(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.

$$3Pb(s) \quad + \quad 8HNO_3(aq) \qquad \longrightarrow \qquad 3Pb(NO_3)_2(aq) \quad + \quad 2NO(g) \quad + \quad 4H_2O(l)$$

(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 dm^3, of nitric acid required for complete reaction.
Give your answer to 3 significant figures

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(3)

(b) In a second experiment, the nitrogen monoxide gas produced in the reaction occupied 638 cm^3 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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(3)

(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.

   ....$Pb(NO_3)_2(s)$ >   .... $PbO(s)$ + ...$NO_2(g)$ + ...$O_2(g)$

(1)
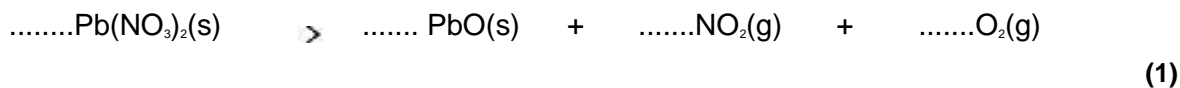
   (ii)   Suggest **one** reason why the yield of nitrogen dioxide formed during this reaction is often less than expected.

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(1)

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

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(1)
(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 $2.2 \times 10^{-3} \times \dfrac{19}{42} \times 100$

B $2.2 \times 10^{-3} \times \dfrac{19}{23} \times 100$

C $2.2 \times 10^{-3} \times \dfrac{9}{20} \times 100$

D $\dfrac{100 \times 19}{2.2 \times 10^{-3}}$

(Total 1 mark)

12. When $TiCl_4$ 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 TiH_2Cl_2

B $TiCl$

C $TiCl_2$

D $TiCl_3$
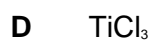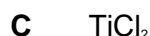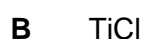
(Total 1 mark)

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 (CH_4) at 100 K

C 1.6 g of oxygen (O_2) at 600 K

D 1.6 g of sulphur dioxide (SO_2) at 1200 K
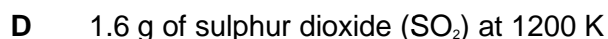
(Total 1 mark)

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

A $CH_3OCH_2CH_3$

B $CH_3OCH_2NH_2$

C COS

D $C_4H_9Al(OH)_2$
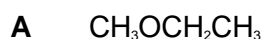
(Total 1 mark)

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

    A   2.65 g

    B   0.0150 m^3 at 1000 K and 33.0 kPa

    C   1.50 dm^3 at 327 °C and 200 kPa

    D   1500 cm^3 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 dm^3 of solution. In this solution the magnesium hydroxide is fully dissociated into ions.

Which one of the following is the concentration of Mg^{2+}(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 Fe_2O_3 (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.

$$2NaHCO_3 \quad Na_2CO_3 + H_2O + CO_2$$

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

    A   613 cm^3

    B   1226 cm^3

    C   613 dm^3

    D   1226 dm^3

(Total 1 mark)