Christ Church
Grammar School

Year 12 Chemistry

Assignment Validation 1
2016

Time allowed: **45 minutes**

Name:_____

Marks: _____ / 33

Question 1 **7 marks**

A common ore of manganese is hausmannite, which contains Mn_3O_4. A particular sample of hausmannite is known to contain 36.3 % Mn_3O_4.

Mn_3O_4 can be reduced to manganese metal by reduction with aluminium as follows

$$3\ Mn_3O_4 + 8\ Al \rightarrow 9\ Mn + 4\ Al_2O_3$$

In a particular process, 1.00 kg of the sample of hausmannite is reacted with 125.0 g of aluminium.

(a) Assuming that the reaction is 100% efficient, determine the limiting reagent and hence calculate the mass of manganese metal that can be obtained?

(7 marks)

Question 2 **8 marks**

A compound is found to contain 18.244 % carbon, 1.276 % hydrogen, 28.350 % oxygen and 52.130 % of an unknown metal, X.

A 7.350 g sample of the compound is analysed for the metal and 2.177 g of Na_2S is required for complete precipitation of the metal as XS. 4.725 g of XS was produced.

(a) Determine the molar mass of metal X and hence its identity. (5 marks)

(b) Determine the empirical formula of the compound. (3 marks)

Question 3 **8 marks**

Fermentation of glucose ($C_6H_{12}O_6$) by yeast is a common method of producing ethanol (C_2H_5OH). Spirits such as vodka and schnapps are traditionally made using potatoes - the potato starch is first broken down into glucose, which then undergoes the fermentation process, as shown below. Under the conditions used, this process is 72% efficient.

$$C_6H_{12}O_6 \rightarrow 2\,C_2H_5OH + 2\,CO_2 \qquad \text{72\% efficient}$$

The amount of ethanol produced may be determined by measuring the amount of CO_2 formed during fermentation.

In a particular analysis, 800 g of potatoes were fermented in a mixture with a total volume of 1.20 L. During the fermentation process, the mass of the reactant mixture decreased by 34.8 g, corresponding to the mass of CO_2 produced.

(a) What volume would the carbon dioxide occupy if it was collected at 120 kPa and at a temperature of 20°C? (2 marks)

(b) Determine the concentration of the ethanol (in $molL^{-1}$) in the fermentation mixture (2 marks)

(c) Determine the percentage by mass of the glucose in the potatoes. (4 marks)

Question 4 **10 marks**

Production of ammonia
Annually 131 million tonnes of ammonia are used in the production of fertilisers worldwide. Presently the Haber Process is used. It accounts for 2% of the world's energy production and 1.9 tonnes of CO_2 are emitted for each tonne of ammonia produced. Alternatives are being sought.

Ammonia from protein
Ammonia can also be produced form organic proteins sources. One example is chicken feathers. They are composed of approximately 90–92% keratin proteins. Recent research has shown that the nitrogen in feathers can be converted to ammonium hydrogencarbonate.

The researchers decomposed 1 g of chicken feathers and 0.26 g of ammonium hydrogencarbonate was recovered.

Ammonium hydrogencarbonate decomposes in the range 36-60 °C to ammonia, carbon dioxide and water, as represented by the equation below.

$$NH_4HCO_3(s) \rightarrow NH_3(g) + CO_2 + H_2O(l) \quad \Delta H = 163 \text{ kJ mol}^{-1}$$

(a) Based on the information above, determine the mass of chicken feathers required to produce 1.00 kg of ammonia. Note: The decomposition of the ammonium hydrogencarbonate is 90% efficient.

(5 marks)

Ammonia from industrial synthesis

The Haber process for the production of ammonia involves the reaction of nitrogen gas from the atmosphere and hydrogen gas from the petrochemical industry to produce ammonia. It is **an exothermic process with high activation energy**. The equation for this reaction is represented below.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H = -ve \qquad \text{Process 1}$$

An alternative industrial synthesis using only air and water in an electrolytic process is being researched. By comparison this process is **endothermic with a low activation energy**. The equation for this process is represented below.

$$2N_2(g) + 6H_2O(g) \rightleftharpoons 4NH_3(g) + 3O_2(g) \quad \Delta H = +ve \qquad \text{Process 2}$$

The table below compares the conditions of temperature and pressure for the 2 processes that would favour a high yield of ammonia.

Reaction conditions for maximum yield of ammonia	Process 1	Process 2
Temperature	low	high
Pressure	high	high

(b) In the Haber Process (**Process 1**) moderate temperature of 500^0C is used. Explain why.

(3 marks)

(c) Explain why high pressure maximises the yield of ammonia in **Process 2.** (2 marks)