UNIT 3BCHE

PENRHOS COLLEGE

STRIVE FOR THE HIGHEST

REACTIONS & STOICHIOMETRY

NAME:_____ **TIME ALLOWED: 60 MINUTES**

Goal Mark: /40
Actual Mark: /40

Section One: **Multiple Choice Questions. (10 marks)**

1. 0.80 g of sulphur trioxide (SO_3) gas contains

   A. 6.0×10^{21} atoms of oxygen
   B. 6.0×10^{21} atoms of sulphur
   C. 1.0×10^{21} molecules of gas
   D. 2.4×10^{22} molecules of gas.

2. All of the following are true relationships except

   A. PV = nRT
   B. R = PV/nT
   C. n = PV /RT
   D. PT= nRV

3. The molar volume of oxygen, in L, at 1.00 atmosphere and 100°C, is closest to

   A. 30.6
   B. 24.5
   C. 22.4
   D. 8.2

4. A 2.00 litre sample of a gas X weighs 2.60 g at $27^{o}C$ and 101.3 kPa. Which of the following could gas X be?

   A. O_2
   B. SO_2
   C. CO_2
   D. F_2

5. When 1.0 mole of Cu_3FeS_3 and 1.0 mole of O_2 are mixed and allowed to react according to the equation

$$\mathbf{2Cu_3FeS_{3(s)} + 7O_{2(g)} \rightarrow 6Cu_{(s)} + 2FeO_{(s)} + 6SO_{2(g)}}$$

A. no reagent is in excess.

B. 5 mole of O_2 is in excess.

C. 5/7 mole of Cu_3FeS_3 is in excess.

D. 2/7 mole of Cu_3FeS_3 is in excess.

6. One possible reaction that occurs when trinitrotoluene (TNT), $C_7H_5N_3O_6$, explodes is

$$\mathbf{2C_7H_5N_3O_{6(s)} \rightarrow 2C_{(s)} + 12CO_{(g)} + 5H_{2(g)} + 3N_{2(g)}}$$

When one mole of TNT explodes the total volume of the gases produced from this reaction, measured at 27 °C and 1.00×10^2 kPa, is **closest** to

A. 0.249 L

B. 22.7 L

C. 249 L

D. 274 L

7. The total concentration of ions in 0.20 mol L^{-1} $Al_2(SO_4)_3$ is:

A. 0.20 mol L^{-1}

B. 0.80 mol L^{-1}

C. 0.60 mol L^{-1}

D. 1.00 mol L^{-1}

8. Sodium azide is used in automobile airbags to provide a source of nitrogen gas for rapid inflation in an accident. The equation shows the production of nitrogen gas from sodium azide.

$$\mathbf{2NaN_{3(s)} \rightarrow 2Na_{(s)} + 3N_{2(g)}}$$

What mass of sodium azide will produce 40 L of N_2 at 100 kPa and 0°C?

A. 70 g

B. 76 g

C. 114 g

D. 172 g

9. A 2 L sample of a gaseous hydrocarbon is burnt in excess oxygen. The only products of the reaction are 8 L of $CO_{2(g)}$ and 10 L of $H_2O_{(g)}$, all at 100ºC and 101.3 kPa pressure.

The formula of the hydrocarbon is

A. CH

B. C_2H_4

C. C_4H_{10}

D. C_8H_{10}

10. If 42 g of Fe powder and 8 g of S powder are mixed and heated, what mass of FeS will be produced?

A. 22 g

C. 44 g

D. 50 g

E. 66 g

End of Section One

Section Two: **Short Answer Questions (15 marks)**

11. A gas is produced when 10.0 g of zinc is placed in 0.50 L of 0.20 mol L^{-1} hydrochloric acid.

A. Write a balanced chemical equation to represent the reaction

1 mark

B. Calculate the volume of gas produced at 25°C and 100 kPa.

3 marks

12. Biodiesel is an alternative to standard diesel fuel. Biodiesel is made from biological ingredients instead of petroleum. Biodiesel is usually made from plant oils or animal fats through a series of chemical reactions.
In one process a common **triglyceride** in palm oil, known as POP, is reacted with methanol in the presence of potassium hydroxide as a catalyst. The result is a mixture of methyl esters of the fatty acids (biodiesel).

A. How many moles of methanol are required to react with one mole of POP?_____
(1 mark)

B. Calculate the volume, in litres, of methanol (density = 0.79 g mL^{-1}) required to react completely with 10.0 kg of the triglyceride POP (Mr = 833) to produce glycerol and the mixture of methyl esters.

4 marks

13. The nitrogen content of bread was determined using the following procedure:

- A sample of bread weighing 2.80 g was analysed.
- The nitrogen in the sample was converted into ammonia.
- The ammonia was collected in 50.0 mL of 0.125 mol L^{-1} hydrochloric acid. All of the ammonia was neutralised, leaving an excess of hydrochloric acid.
- The excess hydrochloric acid was titrated (reacted) with 23.30 mL of 0.116 mol L^{-1} sodium hydroxide solution.

A. Write a balanced equation for the reaction of the hydrochloric acid with sodium hydroxide.

_____

B. Calculate the moles of excess hydrochloric acid.

_____

_____

C. Write a balanced equation for the reaction of the hydrochloric acid with ammonia.

_____

D. Calculate the moles of ammonia.

_____

E. Calculate the percentage by mass of nitrogen in the bread.

_____

_____

_____

6 marks

Sextion Three: **Extended Answer Questions (15 marks)**

15. Chocolate is made from the seeds of a plant called *Theobroma cacao*. Chocolate contains many compounds, including the bitter alkaline substance, theobromine. It is found in the cacao plant and is a water insoluble, crystalline white solid.

The compound theobromine contains the elements carbon, hydrogen, nitrogen and oxygen.

The complete combustion of 3.22 g of the compound released 5.51 g of carbon dioxide and 1.28 g of water.

Further testing of 1.68 g of the compound converted all its nitrogen to NO_2 gas. This gas occupied a volume of 1.12 L, at 100^{o}C and 103 kPa pressure.

A. Determine the empirical formula of theobromine.

6 marks

B. Analysis of the compound indicates that its relative molecular mass is approximately 180. Determine its molecular formula.

2 marks

C. Theobromine is toxic to dogs. The toxicity level is 300 mg per kg of dog.
How much chocolate would a 8.00 kg dog need to consume to poison itself if a particular brand of chocolate on offer contains 2.50 % (by mass) theobromine?

2 marks

16. Drinking and driving is a dangerous combination. It is illegal to drive with a blood-alcohol level above a stated limit. In Western Australia the limit for P-plate (novice) drivers is 0.02% (i.e. 0.02 g alcohol per 100 g blood).

One method of measuring the blood alcohol content (BAC) of a human is the Kozelka and Hine procedure. In this method, protein, aldehydes and ketones are first removed from a blood sample and the purified sample is then reacted with an acidified dichromate solution.

A 25.0 mL sample of blood taken from a driver involved in an accident yielded sufficient alcohol (ethanol) to consume 3.00×10^{-5} moles of $Cr_2O_7^{2-}{}_{(aq)}$ according to the equation:

$$2Cr_2O_7^{2-}{}_{(aq)} + 3CH_3CH_2OH_{(aq)} + 16H^+{}_{(aq)} \rightarrow 4Cr^{3+}{}_{(aq)} + 3CH_3COOH_{(aq)} + 11H_2O_{(l)}$$

A. What observations would be recorded during the procedure?

_____

_____

1 mark

A. Calculate the BAC of the driver expressed in millimoles of ethanol per 100 mL of blood. [Note: 1 millimole = 10^{-3} mole.]

_____

_____

_____

2 marks

B. Assuming that 1.00 mL of blood weighs 1.00 g, calculate the percentage by mass of ethanol in the driver's blood.

_____

_____

_____

2 marks

END OF TEST

UNIT3ACHE **SOLUTIONS**

REACTIONS AND STOICHIOMETRY: Answer all questions

Section One: Multiple Choice Questions (10 marks)

1B	2D	3A	4A	5C	6C	7D	8B	9C	10A

Section Two: Short Answer Questions (16 marks)

11.

A. $Zn_{(s)} + 2HCl_{(aq)} = ZnCl_{2(aq)} + H_{2(g)}$ 1 mark

B. $n = m/M$

$n(Zn) = 10 \div 63.38 = 0.1529$ mol

$n(H_2) = n(Zn) = 0.1529$ mol 1 mark

$n = cV$

$n(HCl) = 0.5 \times 0.02 = 0.1$ mol

$n(H_2) = 1/2 \times n(HCl) = 0.05$ mol 1 mark

HCl is limiting

$PV = nRT$; $V = nRT \div P$

$V(H_2) = 0.05 \times 8.315 \times (273.1 + 25) \div 100 = 1.24$ L 1 mark

[4 marks]

12.

A. 3 1 mark

B. $n(POP) = 10{,}000 \div 833 = 12.00$ mol 1 mark

$n(CH_3OH) = 3 \times 12.00 = 36.01$ mol 1 mark

$m(CH_3OH) = 36.01 \times [12.0 + 4(1.008) + 16] = 36.01 \times 32.042 = 1153.97$ g 1 mark

Density: 0.79 g is equivalent to 1 mL

1.0 g is equivalent to $1 \div 0.79$ mL

1153.97 g is equivalent to $1 \div 0.79 \times 1153.97$ mL = 1460 mL

$V(CH_3OH)$ = 1460 mL or 1.46 L 1 mark

[5 marks]

13.

A. $HCl + NaOH = NaCl + H_2O$ 1 mark

B. $n = cV$

$n(NaOH) = 0.116 \times 0.02330 = 0.002702$ mol 1 mark

$n(HCl)_{inxs} = n(NaOH) = 0.002702$ mol

C. $HCl + NH_3 = NH_4Cl$ or $H^+_{(aq)} + NH_{3(aq)} = NH_4{}^+_{(aq)}$ 1 mark

D. $n(HCl)_{initially} = 0.125 \times 0.05 = 0.00625$ mol 1 mark

$n(NH_3) = n(HCl)_{reacting}$

$= n(HCl)_{initially} - n(HCl)_{inxs} = 0.00625 - 0.002702 = 0.003548$ mol 1 mark

E. $n(N) = n(NH_3) = 0.003548$ mol

$m(N) = 0.003548 \times 14.01 = 0.0497$ g 1 mark

$\%(N) = 0.0497 \div 2.8 \times 100 = 1.78\ \%$ 1 mark

[7 marks]

14.

A. $m(C)_{in\ 3.22\ g}$ = 5.51 x 12.01 ÷ 44.01 g = 1.504 g — 1 mark

%(C) = 1.504 ÷ 3.22 g x 100% = 46.70% — 1 mark

$m(H)_{in\ 3.22\ g}$ = 1.28 x 2(1.008) ÷ 18.016 g = 0.1432 g — 1 mark

%(H) = 0.1432 ÷ 3.22 x 100% = 4.45% — 1 mark

PV = nRT then

$n(NO_2)$ = PV / RT = 103 x 1.12 ÷ (8.315 x (273 + 100))

= 0.03719 mol — 1 mark

n(N) = $n(NO_2)$ = 0.03719 mol

$m(N)_{in\ 1.68\ g}$ = 0.03719 x 14.01 = 0.5211 g — 1 mark

%(N) = 0.5211 / 1.68 x 100% = 31.02% — 1 mark

%(O) = 100 – (46.70 + 4.45 + 31.02) = 17.83% — 1 mark

	C	H	O	N
m =	46.70	4.45	17.83	31.02
n = m/M	46.70/12.01	4.45/1.008	17.83/16	31.02/14.01
n =	3.888	4.419	1.114	2.214
÷ 1.114	3.49	3.97	1	1.99
x 2 to get the smallest whole number ratio				
Formula	7	8	2	4

Therefore EF (theobromine) = $C_7H_8O_2N_4$ — 2 marks

B. m(EF) = 7 x 12.01 + 8 x 1.008 + 2 x 16.00 + 4 x 14.01 = 180.174 — 1 mark

Therefore the EF = MF i.e. MF (theobromine) = $C_7H_8O_2N_4$ — 1 mark

C. Toxicity level (for 8.00 kg dog) = 8.00 x 300 mg = 2400 mg

= 2.40 g theobromine — 1 mark

Mass of brand chocolate = 2.40 x (100 ÷ 2.50) = 96.0 g — 1 mark

[14 marks]