

REACTIONS & STOICHIOMETRY

NAME: _____

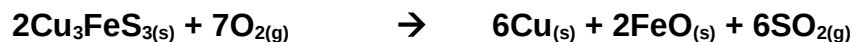
TIME ALLOWED: 60 MINUTES

Goal Mark: /40

Actual Mark: /40

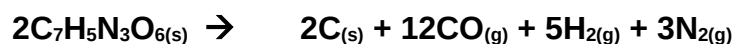
Section One:**Multiple Choice Questions. (10 marks)**

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°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



- 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), $\text{C}_7\text{H}_5\text{N}_3\text{O}_6$, explodes is



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

- A. 0.249 L
- B. 22.7 L
- C. 249 L
- D. 274 L

7. The total concentration of ions in $0.20 \text{ mol L}^{-1} \text{ Al}_2(\text{SO}_4)_3$ 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.



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 $\text{CO}_{2(g)}$ and 10 L of $\text{H}_2\text{O}_{(g)}$, all at 100°C 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 NO₂ gas. This gas occupied a volume of 1.12 L, at 100°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

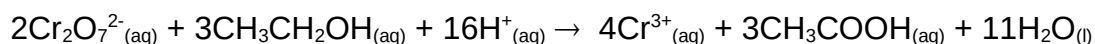
- C. Theobromine is toxic to dogs. The toxicity level is 300 mg per kg of dog. How much chocolate would a 8.00 kg dog need to consume to poison itself if a particular brand of chocolate on offer contains 2.50 % (by mass) theobromine?

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 $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$ according to the equation:



- 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

REACTIONS AND STOICHIOMETRY:

Answer all questions

Section One: Multiple Choice Questions (10 marks)

1B	2D	3A	4A	5C	6C	7D	8B	9C	10A
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Section Two: Short Answer Questions (16 marks)

- 11.
- A. $\text{Zn}_{(s)} + 2\text{HCl}_{(aq)} = \text{ZnCl}_{2(aq)} + \text{H}_{2(g)}$ 1 mark
- B. $n = m/M$
- $n(\text{Zn}) = 10 \div 63.38 = 0.1529 \text{ mol}$
- $n(\text{H}_2) = n(\text{Zn}) = 0.1529 \text{ mol}$ 1 mark
- $n = cV$
- $n(\text{HCl}) = 0.5 \times 0.02 = 0.1 \text{ mol}$
- $n(\text{H}_2) = 1/2 \times n(\text{HCl}) = 0.05 \text{ mol}$ 1 mark
- HCl is limiting
- $PV = nRT$; $V = nRT \div P$
- $V(\text{H}_2) = 0.05 \times 8.315 \times (273.1 + 25) \div 100 = 1.24 \text{ L}$ 1 mark
- [4 marks]
- 12.
- A. 3 1 mark
- B. $n(\text{POP}) = 10,000 \div 833 = 12.00 \text{ mol}$ 1 mark
- $n(\text{CH}_3\text{OH}) = 3 \times 12.00 = 36.01 \text{ mol}$ 1 mark
- $m(\text{CH}_3\text{OH}) = 36.01 \times [12.0 + 4(1.008) + 16] = 36.01 \times 32.042 = 1153.97 \text{ g}$ 1 mark
- Density: 0.79 g is equivalent to 1 mL
- 1.0 g is equivalent to $1 \div 0.79 \text{ mL}$
- 1153.97 g is equivalent to $1 \div 0.79 \times 1153.97 \text{ mL} = 1460 \text{ mL}$
- $V(\text{CH}_3\text{OH}) = 1460 \text{ mL or } 1.46 \text{ L}$ 1 mark
- [5 marks]
- 13.
- A. $\text{HCl} + \text{NaOH} = \text{NaCl} + \text{H}_2\text{O}$ 1 mark
- B. $n = cV$
- $n(\text{NaOH}) = 0.116 \times 0.02330 = 0.002702 \text{ mol}$ 1 mark
- $n(\text{HCl})_{\text{inxs}} = n(\text{NaOH}) = 0.002702 \text{ mol}$
- C. $\text{HCl} + \text{NH}_3 = \text{NH}_4\text{Cl}$ or $\text{H}^+_{(aq)} + \text{NH}_{3(aq)} = \text{NH}_4^+_{(aq)}$ 1 mark
- D. $n(\text{HCl})_{\text{initially}} = 0.125 \times 0.05 = 0.00625 \text{ mol}$ 1 mark
- $n(\text{NH}_3) = n(\text{HCl})_{\text{reacting}}$
- $= n(\text{HCl})_{\text{initially}} - n(\text{HCl})_{\text{inxs}} = 0.00625 - 0.002702 = 0.003548 \text{ mol}$ 1 mark
- E. $n(\text{N}) = n(\text{NH}_3) = 0.003548 \text{ mol}$
- $m(\text{N}) = 0.003548 \times 14.01 = 0.0497 \text{ g}$ 1 mark
- $\%(\text{N}) = 0.0497 \div 2.8 \times 100 = 1.78 \%$ 1 mark
- [7 marks]

14.

A. $m(C)_{in\ 3.22\ g} = 5.51 \times 12.01 \div 44.01\ g = 1.504\ g$ 1 mark
 $\% (C) = 1.504 \div 3.22\ g \times 100\% = 46.70\%$ 1 mark

$m(H)_{in\ 3.22\ g} = 1.28 \times 2(1.008) \div 18.016\ g = 0.1432\ g$ 1 mark
 $\% (H) = 0.1432 \div 3.22 \times 100\% = 4.45\%$ 1 mark

PV = nRT then

$n(NO_2) = PV / RT = 103 \times 1.12 \div (8.315 \times (273 + 100))$
 $= 0.03719\ mol$ 1 mark

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

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

$\% (N) = 0.5211 / 1.68 \times 100\% = 31.02\%$ 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. $m(EF) = 7 \times 12.01 + 8 \times 1.008 + 2 \times 16.00 + 4 \times 14.01 = 180.174$ 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) = $8.00 \times 300\ mg = 2400\ mg$
 $= 2.40\ g\ theobromine$ 1 mark

Mass of brand chocolate = $2.40 \times (100 \div 2.50) = 96.0\ g$ 1 mark

[14 marks]