

## Hale School Semester One Practice Examination

### CHEMISTRY Stage 3

Write your name below:

**For Examiners only**

**TIME ALLOWED FOR THIS PAPER**

Reading time before commencing: Ten  
Working time for paper: Three

### MATERIAL REQUIRED/RECOMMENDED FOR THIS PAPER

#### *TO BE PROVIDED BY THE SUPERVISOR*

This Question/Answer booklet  
Separate Multiple Choice Answer sheet for Part 1.  
Separate Question and Answer Booklet for Part 3.  
A Chemistry Data Sheet.

#### *TO BE PROVIDED BY THE CANDIDATE*

Standard Items: Pens, pencils, eraser, ruler

Special Items: A calculator satisfying the conditions set by the Curriculum Council, and a '2B' pencil for the separate Multiple Choice Answer sheet.

### IMPORTANT NOTE TO CANDIDATES

No other items may be taken into the examination room.

It is your responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. Please check carefully, and if you have any unauthorised material with you, hand it to the supervisor **BEFORE** reading any further.

## INSTRUCTIONS TO CANDIDATES

Answer **ALL** questions - This paper consists of **THREE PARTS** as follows:

**PART 1** contains **25 questions**. It is a multiple choice test.

Answer **ALL** questions in Part 1 on the Separate Multiple Choice Answer Sheet. Use a '**2B**' **PENCIL. DO NOT USE A BALL POINT OR INK PEN**. If you consider that two or more of the alternative answers are correct then select the **BEST** alternative. Marks will **NOT** be deducted for incorrect answers. This part is worth 50 marks and should take about 45 minutes.

**Use pen for parts 2 and 3.**

**PART 2** contains **9 short answer questions**. You should answer **ALL** the questions. The answers are to be written in the spaces provided in this Examination booklet. This part is worth 75 marks and should take about 65 minutes.

**PART 3** (*separate booklet*) contains **6 calculations with theoretical applications and an extended response of approximately one (1) page**. You should answer **ALL** the questions in detail in a **separate answer booklet**. This part is worth 67 marks and should take about 70 minutes.

At the end of the examination make sure that your **Name** is on your Examination paper and the Part 3 Question and Answer Booklet and your Multiple Choice Answer Sheet.

### Chemical Equations

**For full marks, chemical equations should refer only to those species consumed in the reaction and any new species produced. These species may be ions [for example  $\text{Ag}^+(\text{aq})$ ], molecules [for example  $\text{NH}_3(\text{g})$ ,  $\text{NH}_3(\text{aq})$ ,  $\text{CH}_3\text{COOH}(\text{l})$ ,  $\text{CH}_3\text{CHOOH}(\text{aq})$ ] or solids [for example  $\text{BaSO}_4(\text{s})$ ,  $\text{Cu}(\text{s})$ ,  $\text{Na}_2\text{CO}_3(\text{s})$ ].**

### Part 1 (50 marks)

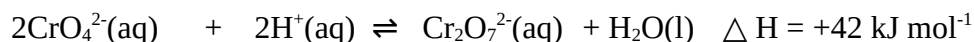
Answer ALL questions in Part 1 on the separate Multiple Choice Answer Sheet provided, using a 2B, B or HB pencil. Each question is worth 2 marks.

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1. Isoelectronic species are those with the same electron configuration. Which of the following pairs are not isoelectronic species?
  - a.  $\text{K}^+$  and  $\text{Cl}^-$
  - b.  $\text{O}^{2-}$  and  $\text{F}^-$
  - c.  $\text{Mg}^{2+}$  and  $\text{Ca}^{2+}$
  - d.  $\text{Na}^+$  and Ne
  
2. Assuming that the following compounds all have exactly tetrahedral structures, which one would have the strongest dispersion forces?
  - a. methane
  - b. dichloromethane
  - c. chloromethane
  - d. tetrachloromethane

The next two questions refer to the following information.

When dilute hydrochloric acid is added to a solution of potassium chromate, a solution of potassium dichromate is produced. This is an example of a reversible reaction where there are no visible changes to the colour of the solution formed once equilibrium has been reached.



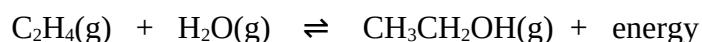
3. Which one of the following would favour the forward reaction?
  - a. Addition of potassium chloride
  - b. Increasing the concentration of hydrochloric acid.
  - c. Decreasing the temperature of the solution.
  - d. Addition of potassium dichromate.
  
4. What would you expect to happen to the colour of this solution if dilute sodium hydroxide is added?
  - a. The solution would become more intensely orange due to the forward reaction being favoured.
  - b. The solution would become yellow due to the reverse reaction being favoured.
  - c. The solution would remain orange due to the fact that sodium hydroxide is not one of the reacting species in this reaction.
  - d. The solution would become colourless due to the forward reaction producing more water molecules.

5. Some solid barium carbonate is added to dilute nitric acid. Which of the following equations **best** represents the **reaction** that takes place?
- $\text{BaCO}_3(\text{s}) + 2\text{HNO}_3(\text{aq}) \rightarrow \text{Ba}(\text{NO}_3)_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$
  - $\text{BaCO}_3(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{Ba}^{2+}(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$
  - $\text{Ba}^{2+}(\text{aq}) + 2\text{NO}_3^-(\text{aq}) \rightarrow \text{Ba}(\text{NO}_3)_2(\text{s})$
  - $\text{CO}_3^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$
6. Which one of the following 0.1 mol L<sup>-1</sup> aqueous solutions contains the highest concentration of solute particles (that is, molecules and ions)?
- acetic acid (ethanoic acid), CH<sub>3</sub>COOH
  - 1,2-ethanediol (ethylene glycol), HOCH<sub>2</sub>CH<sub>2</sub>OH
  - sodium chloride, NaCl
  - sodium sulfate, Na<sub>2</sub>SO<sub>4</sub>
7. Which one of the following substances is non-polar but consists of molecules in which there are polar covalent bonds?
- Tetrafluoromethane CF<sub>4</sub>.
  - Bromine Br<sub>2</sub>.
  - Hydrogen sulfide H<sub>2</sub>S.
  - Hydrogen chloride HCl.
8. An element Z has the following five successive molar ionisation energies (in kJ mol<sup>-1</sup>): 740, 1500, 7700, 10500, 13600. What would be the formula of the compound formed when Z reacts with oxygen?
- Z<sub>2</sub>O
  - ZO
  - ZO<sub>2</sub>
  - Z<sub>3</sub>O<sub>4</sub>
9. A particular isotope of carbon is designated <sup>14</sup><sub>6</sub>C. An atom of this isotope contains which of the following?
- 6 protons, 8 neutrons and 6 electrons.
  - 8 protons, 14 neutrons and 8 electrons.
  - 6 protons, 8 neutrons and 14 electrons.
  - 6 protons, 6 neutrons and 14 electrons.
10. Which of the following statements is the best definition of ionisation energy?

- a. It is the energy required to dissociate one mole of ions in the solid phase.
  - b. It is the energy absorbed when a mole of an ionic substance dissolves in water.
  - c. It is the energy required to form one mole of an ionic substance from its constituent atoms.
  - d. It is the energy required to remove a mole of electrons from a mole of atoms or ions of an element in the gaseous phase.
11. Which two stresses will each cause the equilibrium to shift to the left in the following system?
- $$\text{CO}_2(\text{g}) + \text{H}_2(\text{g}) \rightleftharpoons \text{H}_2\text{O}(\text{g}) + \text{CO}(\text{g})$$
- a. increase  $[\text{H}_2]$  , increase  $[\text{CO}]$
  - b. decrease  $[\text{H}_2]$  , increase  $[\text{H}_2\text{O}]$
  - c. increase  $[\text{CO}_2]$  , decrease  $[\text{CO}]$
  - d. decrease  $[\text{CO}_2]$  , decrease  $[\text{H}_2\text{O}]$
12. In every solubility equilibrium system, the rate of dissolving is
- a. equal to zero.
  - b. equal to the rate of crystallisation.
  - c. less than the rate of crystallisation.
  - d. greater than the rate of crystallisation.
13. A sealed vessel contains 0.200 mol of oxygen gas, 0.100 mol of nitrogen gas, and 0.200 mol of argon gas. The total pressure of the gas mixture is 25.00 atm. The partial pressure of the argon is
- a. 0.200 atm
  - b. 1.00 atm
  - c. 10.00 atm
  - d. 12.50 atm
  - e. 5.00 atm
14. In which one of the following does the central atom not possess an 'octet' in its outer shell?
- a.  $\text{CH}_4$
  - b.  $\text{BH}_3$
  - c.  $\text{NH}_3$
  - d.  $\text{H}_2\text{O}$
15. A mixture of 0.6g of hydrogen and 3.4g of ammonia in a flask exerts

total pressure of 1.0 atmosphere at 300°K. What is the partial pressure of ammonia ?

- a. 0.20 atmosphere
  - b. 0.25 atmosphere
  - c. 0.40 atmosphere
  - d. 0.60 atmosphere
  - e. 0.75 atmosphere
16. Which of the following pairs do not form a coordinate (dative) covalent bond to each other?
- a.  $\text{NH}_3$  and  $\text{H}^+$
  - b.  $\text{BF}_3$  and  $\text{NH}_3$
  - c.  $\text{CH}_4$  and  $\text{AlCl}_3$
  - d.  $\text{H}_2\text{O}$  and  $\text{H}^+$
17. Ethanol can be manufactured industrially by the reaction of ethene and water in the presence of an acid catalyst as shown by the equilibrium below.



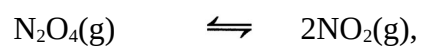
- Which of the following changes to the system would increase the yield of ethanol?
- a. increase the temperature.
  - b. increase the partial pressure of ethanol.
  - c. use more acid catalyst.
  - d. use high pressure steam in the reaction.
18. Which of the following statements about the periodic table is false?
- a. The number of protons increases across a period.
  - b. Atomic radius decreases across a period.
  - c. Group 18 elements are generally unreactive.
  - d. Electronegativity increases down a group.
19. 25.0 mL of  $1.50 \text{ mol L}^{-1}$  sulfuric acid is reacted with 9.25g of barium nitrate. What mass of precipitate is produced?
- a. 8.75g
  - b. 0.00g
  - c. 8.26g
  - d. 4.23g
  - e. 4.38g
20. Using the information from question 22 determine the new concentration of sulfuric acid. Assume the volume is unchanged at the end of the reaction.

- a.  $0.00 \text{ molL}^{-1}$   
 b.  $0.042 \text{ molL}^{-1}$   
 c.  $0.083 \text{ molL}^{-1}$   
 d.  $1.50 \text{ molL}^{-1}$
21. You are required to make a 750 mL solution of  $0.25 \text{ molL}^{-1}$  nitric acid solution using a  $5.50 \text{ molL}^{-1}$  stock solution of nitric acid. The volume of water you would need to add to the stock solution would be
- a. 358mls  
 b. 716mls  
 c. 666mls  
 d. 375mls
22. A gardener wishes to make a soluble fertiliser which will provide a source of nitrogen, phosphorus and potassium. Which one of these mixtures will produce a completely soluble fertiliser solution when added to water?
- a.  $\text{Na}_3\text{PO}_4$        $\text{Ca}(\text{NO}_3)_2$        $\text{KCl}$   
 b.  $\text{K}_2\text{CO}_3$        $\text{Ba}(\text{NO}_3)_2$        $\text{K}_3\text{PO}_4$   
 c.  $\text{K}_2\text{SO}_4$        $\text{NH}_4\text{Cl}$        $\text{Na}_3\text{PO}_4$   
 d.  $\text{Ca}(\text{NO}_3)_2$        $\text{KNO}_3$        $\text{Na}_3\text{PO}_4$

Study the table below showing some data for the halogens .

HALOGEN	ATOMIC NUMBER	MOLECULAR MASS	MELTING POINT ( $^{\circ}\text{C}$ )
$\text{F}_2$	9	38	-220
$\text{Cl}_2$	17	71	-101
$\text{Br}_2$	35	160	-7
$\text{I}_2$	53	254	114

23. Which one of the following statements best explains why the boiling points of the halogens increase with increasing atomic number?
- a) The number of electrons increases, resulting in the formation of more covalent bonds.  
 b) The number of electrons increases, resulting in stronger dispersion forces between molecules.  
 c) The increased number of electrons causes the molecules to be more polar.  
 d) As the molecular masses increase, so too do the sizes of the molecules, resulting in stronger ionic bonds between the ions.
24. What would happen to the value of the equilibrium constant (k) in the reaction described below:



if the pressure of the  $\text{N}_2\text{O}_4$  is doubled?

- a)  $k$  would not be affected.
  - b)  $k$  would be halved.
  - c)  $k$  would be doubled.
  - d)  $k$  would increase by a factor of 4.
25. 100 g of mineral water was found to contain 0.00584 g of  $\text{NaCl}$ . What is the concentration of  $\text{NaCl}$  in parts per million by mass?
- a) 1.00
  - b) 5.84
  - c) 58.4
  - d) 584

## Part 2 (75 marks)

Answer ALL questions in Part 2 in the spaces provided below. This section contains 9 questions.

SEE NEXT PAGE



1. Complete the following table.

Name	Formula (½ mark)	Electron dot diagram (Lewis diagram) (1 marks)	Polar/Non-polar (½ mark)
Nitrate ion			
Chloromethane			
Ammonia			
Boron trifluoride			

(8 marks)

2. Use nickel (II) sulfate, which has a solubility of 65.0g/100 mL of water at 20.0°C, to answer the following.
- a. What colour would a solution of nickel sulfate be?
- b. Write an appropriate equation showing the reaction of a solution of nickel sulfate with a solution of barium nitrate.

(1 mark)

(2 marks)

2. continued.

- c. Describe what you would observe in the reaction from part b.

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(1mark)

- d. What mass of nickel sulfate would need to be added to 3.00 mL of water, at 20.0°C to make a saturated solution?

(2 marks)

- e. Draw a diagram representing the equilibrium established when 75.0g of nickel sulfate is added to 100 mL of water at 20.0°C. Assume no water is evaporating. Label clearly.

(4 marks)

- f. Explain the following properties of nickel sulfate;

Electrical conductivity

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(2 marks)

2 continued.

It is a brittle solid

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(2 marks)

- g. Draw an electron dot diagram for nickel (II) sulfate.

(2 marks)

3. Explain the chemistry behind these daily situations.

- a. Baking powder (sodium hydrogen carbonate) is added to a cake mix before baking.

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(2 marks)

- b. McDonald's restaurants put crushed ice into drinks.

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(2 marks)

- c. The sublimation of carbon dioxide is favoured as temperature increases.

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(2 marks)

- d. Bromine is used in spas for the same reason chlorine is used in swimming pools. Spas are warmer than pools so why use bromine?

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( 2 marks)

4. Write equations for any reactions that occur in the following procedures. If no reaction occurs write 'no reaction'.

In each case fully describe what you would observe, including any: colours; odours; precipitates (give the colour); or gases evolved (give the colour or describe as colourless). If no change is observed you should state this.

- a. Lead(II) nitrate solution is added slowly to sodium iodide solution.

**Equation** \_\_\_\_\_

**Observation** \_\_\_\_\_

(3 marks)

- b. Dilute sulfuric acid is added to solid calcium carbonate.

**Equation** \_\_\_\_\_

**Observation** \_\_\_\_\_

(3 marks)

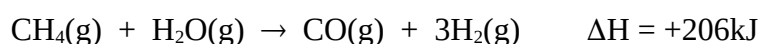
- c. Solid copper (II) carbonate is heated strongly.

**Equation** \_\_\_\_\_

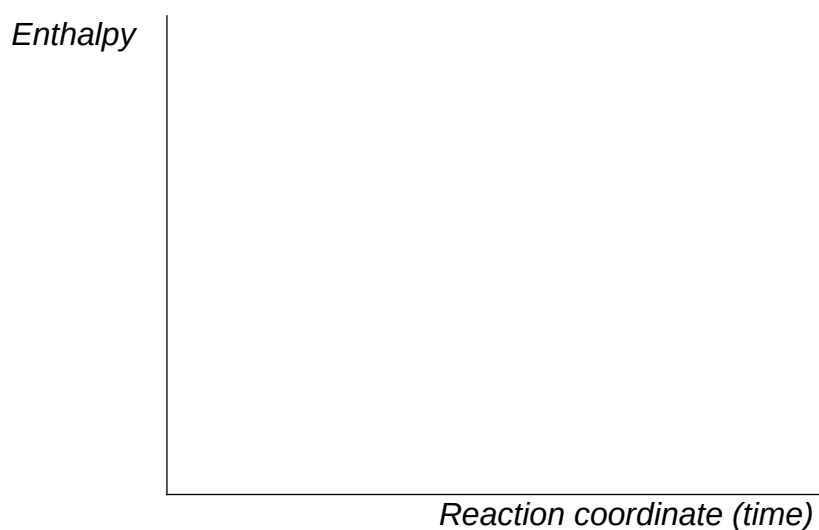
**Observation** \_\_\_\_\_

(3 marks)

5. Consider the following reaction:

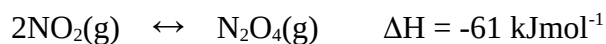


Under normal laboratory conditions the reaction is very slow. Sketch and label a diagram that represents the change in enthalpy for the reaction.



(3 marks)

6. Consider the equilibrium established between nitrogen dioxide (a brown gas) and dinitrogen tetroxide (a colourless gas) in a sealed container:



At room temperature the equilibrium mixture has a pale brown appearance.

If the changes below are then imposed on the system at equilibrium, clearly state what you would observe after each change is made, and apply Le Chatelier's Principle to account for each observation.

- a. the pressure on the gas mixture is halved by doubling the volume of the container.

**Observation** \_\_\_\_\_ (1 mark)

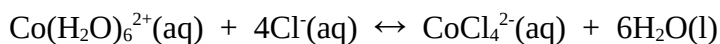
**Explanation** \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (3 marks)

- b. the temperature of the gas mixture is increased

**Observation** \_\_\_\_\_ (1 mark)

**Explanation** \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (3 marks)

7. Consider the equilibrium established between the pink aquated cobalt ion,  $\text{Co}(\text{H}_2\text{O})_6^{2+}$ , and the blue cobalt chloride ion,  $\text{CoCl}_4^{2-}$ :



If the changes below are then imposed on the system at equilibrium, clearly state what you would observe after each change is made, and apply Le Chatelier's Principle to account for each observation.

- (a) some concentrated hydrochloric acid is added to the solution

**Observation** \_\_\_\_\_ (1 mark)

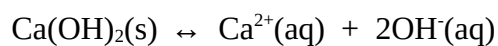
**Explanation** \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (3 marks)

- (b) some silver nitrate is added to the solution

**Observation** \_\_\_\_\_ (1 mark)

**Explanation** \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (3 marks)

8. Three solutions of calcium hydroxide were prepared in different flasks. In each there was a slight excess of the calcium hydroxide so that some remained undissolved and the following equilibrium established at 25.0°C



- a. Write the equilibrium constant expression for the reaction:

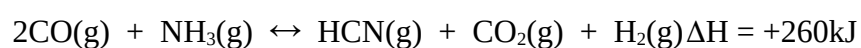
(2 marks)

- b. The solutions were then used in the three experiments described in the table below. For each state your expected observations and explain them using appropriate chemical theory.

Flask	Experiment	Observation	Explanation
1	A small amount of $10\text{molL}^{-1}$ $\text{HCl}_{(\text{aq})}$ was added.		
2	A small amount of concentrated $\text{NaOH}_{(\text{aq})}$ was added.		
3	A small volume of $\text{CO}_{2(\text{g})}$ was bubbled through the solution.		

(9 marks)

9. An industrial method for the production of hydrogen cyanide involves the reaction between carbon monoxide and ammonia gas:



State one method that you could use to increase the yield of hydrogen cyanide (i.e. the amount present at equilibrium) without decreasing the rate at which the hydrogen cyanide is produced. Explain your answer.

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(4 marks)

**END OF PART 2**



### Part 3 (67 marks)

Answer ALL questions in Part 3 in this booklet. Answers are to be set out in detail. Marks will be allocated for correct equations and clear setting out, even if you cannot complete the problem. This section contains 6 questions. All numerical answers expressed to 3 significant figures.

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1. (13 marks)

A particular brand of soft drink uses an artificial sweetener for their diet brands. This sweetener is analysed to ensure it conforms to Australian Food Standards. A combustion analyses of a 1.021g sample of the sweetener produced 1.715g carbon dioxide, 0.2521g nitrogen dioxide, 0.2521 g of water and 0.3568g of sulphur dioxide. The sweetener contains the elements C, H, O, N and S. Determine the empirical formula of the artificial sweetener.



2. (14 marks)

A blast furnace is a large furnace operated at very high temperatures to convert iron (III) oxide to iron using carbon monoxide, which is itself converted to carbon dioxide in the process.

a) Write an equation depicting the reaction described.

b) Use your knowledge of reaction rates and equilibrium to answer the following;

i) reaction occurs at high temperatures

ii) what do you think is done to ensure equilibrium is never reached in this reaction?

b) If 1.00 tonne of iron ore containing 96.5% iron (III) oxide is fed into the blast furnace with  $2.70 \times 10^6$  L of carbon monoxide gas at 1.12 atm of pressure and 1986°C.

i) Determine the limiting reagent.

ii) What mass of iron is produced in this reaction?

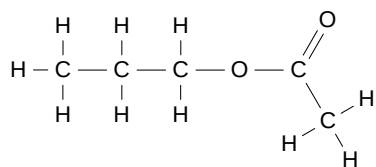
iii) Calculate the mass of excess reactant.

iv) If  $5.56 \times 10^{-1}$  tonne of iron is produced then determine the percentage yield of the process.

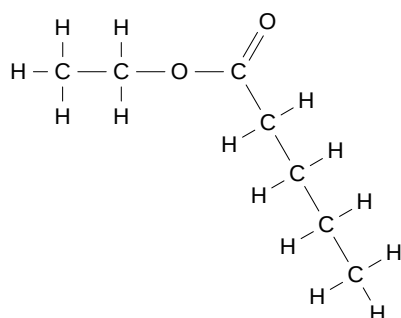
3. (11 marks)

An industrial chemist is working with esters to create a fruity smelling shampoo.

Propylethanoate smells of pears and has the structure;



Ethylpentanoate smells of apples and has the structure;



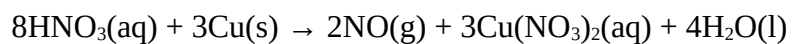
Unfortunately the chemist has a cold and cannot tell the difference between the two esters. To enable identification she decides to perform a combustion analysis on one of the esters and then determine its empirical formula.

A 3.40 g sample of the ester produced 8.06 g CO<sub>2</sub> and 3.30 g H<sub>2</sub>O on combustion. Determine which ester she has identified.



4. (9 marks)

1.037 g of copper metal was added to 25.0 mL of an 8.00 mol L<sup>-1</sup> solution of nitric acid. The reaction that occurred can be represented by the following equation:



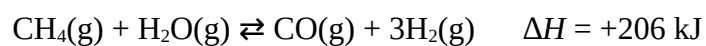
- a) What is the limiting reagent in the reaction?
- b) What volume of nitrogen monoxide will be produced at 125.0 kPa and 30.0°C?
- c) Calculate the number of moles of excess reactant

5. (8 marks)

Consider the following mixture of gases in a closed 5.00 L vessel at 730.0°C.

<i>Gas</i>	<i>Quantity (mol)</i>
CH <sub>4</sub>	2.00
H <sub>2</sub> O	1.25
CO	0.75
H <sub>2</sub>	0.75

The following reaction is occurring:



The equilibrium constant,  $K$ , is 0.26 at 730.0°C.

a) Write the equilibrium constant expression for the reaction.

b) Determine whether the system is at equilibrium.

c) Explain how conditions in this reaction could be adjusted to increase the quantity of products.

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6. (12 marks)

The Haber process is the process for the production of ammonia.

a) Write an equation to represent the Haber process.

b) Draw a flowchart for the Haber process.

c) The reaction is carried out at a temperature of 450°C. Explain this choice of temperature in terms of both reaction rate and yield.

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- d) What is the catalyst used in the Haber process? Why is it necessary?

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- e) What is the approximate pressure used in the Haber process? Why is this pressure chosen? Explain in terms of equilibrium.

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**END OF PART 3**

**END OF EXAMINATION**