Hale School
Semester One Practice Examination

Write your name below:

Solutions

CHEMISTRY
Stage 3

TIME ALLOWED FOR THIS PAPER

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

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.

SEE NEXT PAGE

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 $Ag^+(aq)$], molecules [for example $NH_3(g)$, $NH_3(aq)$, $CH_3COOH(l)$, $CH_3CHOOH(aq)$] or solids [for example $BaSO_4(s)$, $Cu(s)$, $Na_2CO_3(s)$].

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.

_____

1.   Isoelectronic species are those with the same electron configuration. Which of the following pairs are not isoelectronic species?

    a. K^+ and Cl^-
    b. O^{2-} and F^-
    c. Mg^{2+} and Ca^{2+}
    d. 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
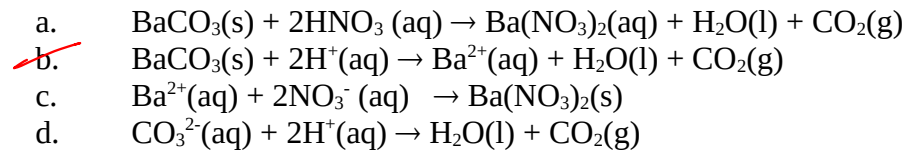   c.   chloromethane
    d.   tetrachloromethane

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.

$$2CrO_4^{2-}(aq) \quad + \quad 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l) \quad \triangle H = +42 \text{ kJ mol}^{-1}$$
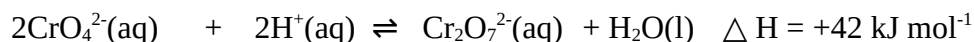
3.   Which one of the following would favour the forward reaction?

    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.

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5. Some solid barium carbonate is added to dilute nitric acid. Which of the following equations **best** represents the **reaction** that takes place?

    a. $BaCO_3(s) + 2HNO_3(aq) \rightarrow Ba(NO_3)_2(aq) + H_2O(l) + CO_2(g)$
    b. $BaCO_3(s) + 2H^+(aq) \rightarrow Ba^{2+}(aq) + H_2O(l) + CO_2(g)$
    c. $Ba^{2+}(aq) + 2NO_3^-(aq) \rightarrow Ba(NO_3)_2(s)$
    d. $CO_3^{2-}(aq) + 2H^+(aq) \rightarrow H_2O(l) + CO_2(g)$

6. Which one of the following 0.1 mol L^{-1} aqueous solutions contains the highest concentration of solute particles (that is, molecules and ions)?

    a.   acetic acid (ethanoic acid), CH_3COOH
    b.   1,2-ethanediol (ethylene glycol), $HOCH_2CH_2OH$
    c.   sodium chloride, $NaCl$
    d.   sodium sulfate, Na_2SO_4

7. Which one of the following substances is non-polar but consists of molecules in which there are polar covalent bonds?

    a.   Tetrafluoromethane CF_4.
    b.   Bromine Br_2.
    c.   Hydrogen sulfide H_2S.
    d.   Hydrogen chloride HCl.

8. An element Z has the following five successive molar ionisation energies (in kJ mol^{-1}): 740, 1500, 7700, 10500, 13600. What would be the formula of the compound formed when Z reacts with oxygen?

    a. Z_2O
    b.   ZO
    c. ZO_2
    d. Z_3O_4

9. A particular isotope of carbon is designated $^{14}_6C$. An atom of this isotope contains which of the following?

    a.   6 protons, 8 neutrons and 6 electrons.
    b.   8 protons, 14 neutrons and 8 electrons.
    c.   6 protons, 8 neutrons and 14 electrons.
    d.   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?

$$CO_2(g) + H_2(g) \rightleftharpoons H_2O(g) + CO(g)$$

a. increase[H_2] , increase [CO]
b. decrease [H_2] , increase [H_2O]
c. increase [CO_2] , decrease [CO]
d. decrease [CO_2] , decrease [H_2O]

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. CH_4
b. BH_3
c. NH_3
d. H_2O

15. A mixture of 0.6g of hydrogen and 3.4g of ammonia in a flask exerts

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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. NH_3 and H^+
    b. BF_3 and NH_3
    c. CH_4 and $AlCl_3$
    d. H_2O and 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.

$$C_2H_4(g) \ + \ H_2O(g) \ \rightleftharpoons \ CH_3CH_2OH(g) \ + \ energy$$
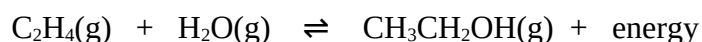
Which of the following changes to the system would increase the yield of ethanol?
    a.   increase the temperature.
    b.   increase the partial pressure of ethanol.
    c.   use more acid catalyst.
    d.   use high pressure steam in the reaction.

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 $molL^{-1}$ 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 molL^{-1}
b. 0.042 molL^{-1}
c. 0.083 molL^{-1}
d. 1.50 molL^{-1}

21.   You are required to make a 750 mL solution of 0.25 molL^{-1} nitric acid solution using a 5.50 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.	Na_3PO_4	$Ca(NO_3)_2$	KCl
b.	K_2CO_3	$Ba(NO_3)_2$	K_3PO_4
c.	K_2SO_4	NH_4Cl	Na_3PO_4
d.	$Ca(NO_3)_2$	KNO_3	Na_3PO_4

Study the table below showing some data for the halogens .

HALOGEN	ATOMIC NUMBER	MOLECULAR MASS	MELTING POINT (ºC)
F_2	9	38	-220
Cl_2	17	71	-101
Br_2	35	160	-7
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:

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$,
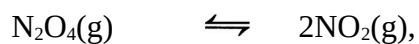
if the pressure of the N_2O_4 is doubled?

temp change

K

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 NaC*l*. What is the concentration of NaC*l* in parts per million by mass?

a) 1.00
b) 5.84
c) 58.4
d) 584

$\frac{5.84 \text{ mg}}{0.1 \text{ kg}} = 58.4$

Part 2 (75 marks)

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

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1. Complete the following table.

Name	Formula (½ mark)	Electron dot diagram (Lewis diagram) (1 marks)	Polar/Non-polar (½ mark)
Nitrate ion	NO_3^-	*(handwritten Lewis structure)*	NP
Chloromethane	CH_3Cl	*(handwritten Lewis structure)*	P
Ammonia	NH_3	*(handwritten Lewis structure)*	P
Boron trifluoride	BF_3	*(handwritten Lewis structure)*	NP

(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?   green

(1 mark)

b. Write an appropriate equation showing the reaction of a solution of nickel sulfate with a solution of barium nitrate.

$$Ba^{2+}_{(aq)} + SO_4^{2-}_{(aq)} \rightarrow BaSO_4{(s)}$$
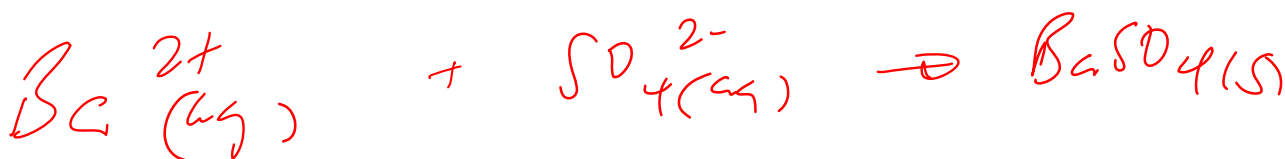
(2 marks)

2. continued.

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

*green solution added to colourless solution. White ppt forms and green solution fades.*

(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?

1.95 g

(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.
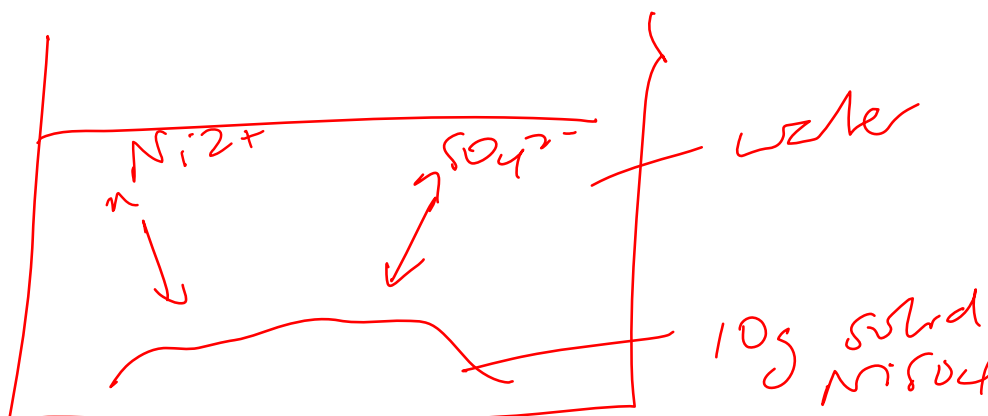
(4 marks)

f. Explain the following properties of nickel sulfate;

Electrical conductivity

Non-conductor as a solid (1)
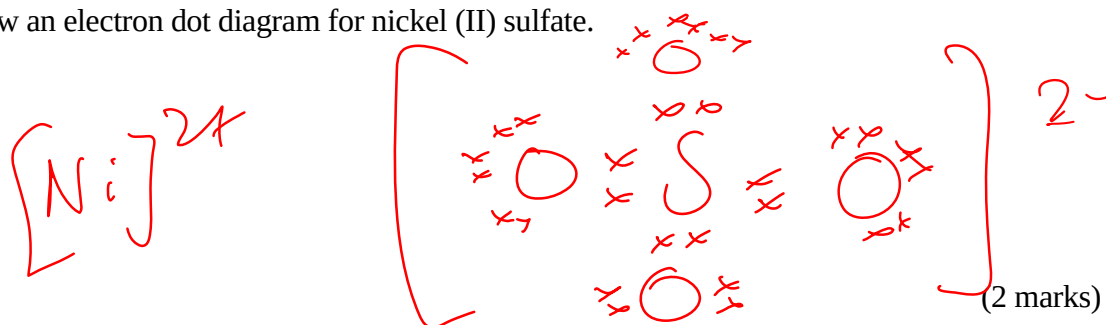*Conducts in molten or*
aqueous states

(2 marks)

2 continued.

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It is a brittle solid

Directional bonding, ∴ force can shift planes causing like charges to oppose each other.

(2 marks)

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

$[Ni]^{2+}$

(2 marks)

3. Explain the chemistry behind these daily situations.

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

Decomposition creates CO_2 which helps cake rise

(2 marks)

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

↑ SA makes drinks colder, faster

OR cold liquid stay fizzier

(2 marks)

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

$CO_2 (s) \rightarrow CO_2 (g)$ is endo ∴ favoured by ↑ temp.

(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?

Greater dispersion forces ∴ more soluble at higher temps

(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 $Pb^{2+}_{(aq)} + 2I^-_{(aq)} \rightarrow PbI_{2(s)}$

**Observation** two clear colourless sol^n added to produce yellow ppt

(3 marks)

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

Equation $2H^+_{(aq)} + CaCO_{3(s)} \rightarrow CO_{2(g)} + H_2O_{(l)} + Ca^{2+}_{(aq)}$

Observation White solid added to colourless solution, solid dissolves and colourless odourless gas is formed.
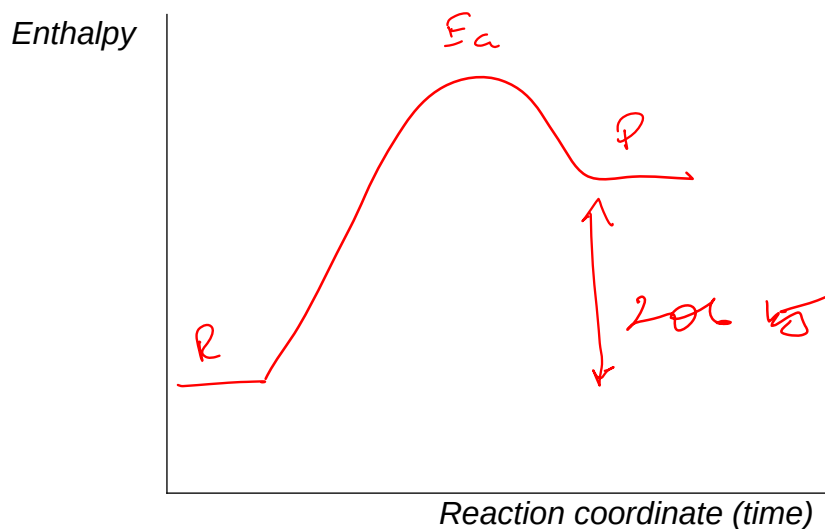
(3 marks)

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

Equation $CuCO_{3(s)} \rightarrow CO_{2(g)} + CuO_{(s)}$

Observation blue/green solid is heated to produce black solid

(3 marks)

5. Consider the following reaction:

$$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g) \qquad \Delta H = +206kJ$$
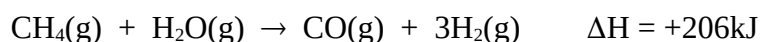
Under normal laboratory conditions the reaction is very slow. Sketch and label a diagram that represents the change in enthalpy for the reaction.

Reaction coordinate (time)

(3 marks)

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

$$2NO_2(g) \leftrightarrow N_2O_4(g) \qquad \Delta H = -61 \text{ kJmol}^{-1}$$
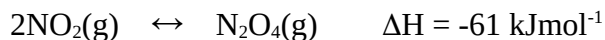
At room temperature the equilibrium mixture has a pale brown appearance.

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** _fades then darkens_

(1 mark)

Explanation _____
fades as conc of all gas decreases.
A equilibrium is established
the reaction darkens

(3 marks)

b. the temperature of the gas mixture is increased

Observation _mixture will darken_

(1 mark)

Explanation _____
reverse rxn is favoured
by ↑ temp

(3 marks)

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7. Consider the equilibrium established between the pink aquated cobalt ion, $Co(H_2O)_6^{2+}$, and the blue cobalt chloride ion, $CoCl_4^{2-}$:
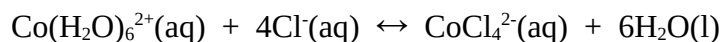
$$Co(H_2O)_6^{2+}(aq) \ + \ 4Cl^-(aq) \ \leftrightarrow \ CoCl_4^{2-}(aq) \ + \ 6H_2O(l)$$

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 _____ go blue _____

(1 mark)

Explanation _____ [Cl⁻] ↑ favours _____

_____ forward rxn _____

_____

_____

_____

(3 marks)

(b)   some silver nitrate is added to the solution

Observation _____ go pink _____

(1 mark)

Explanation _____

Ag⁺ ppt out Cl⁻ ∴ reducing

[Cl⁻] ∴ reverse rxn is favoured.

_____

_____

(3 marks)

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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

$$Ca(OH)_2(s) \leftrightarrow Ca^{2+}(aq) + 2OH^-(aq)$$
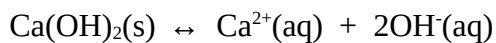
a. Write the equilibrium constant expression for the reaction:

$$K = [Ca^{2+}][OH^-]^2 \quad @ \quad 25°C$$

(2 marks)

b. The solutions where 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 10molL⁻¹ HCl₍aq₎ was added.	some solid dissolves	$[OH^-]\downarrow$ as $H^+ + OH^- \rightarrow H_2O$ ∴ rxn pushes to the right to reestablish
2	A small amount of concentrated NaOH₍aq₎ was added.	more solid produced	$[OH^-]\uparrow$ ∴ rxn pushes to the left. $[Ca^{2+}]$ is $\downarrow$
3	A small volume of CO₂₍g₎ was bubbled through the solution.	Ca(OH)₂₍s₎ dissolves CaCO₃ ppt produced	∴ rxn pushes to right. CaCO₃₍s₎ is produced

(9 marks)

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

$$2CO(g) + NH_3(g) \leftrightarrow HCN(g) + CO_2(g) + H_2(g) \quad \Delta H = +260kJ$$
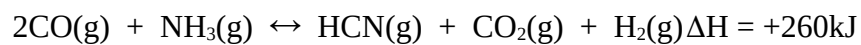
State one method that you could use to increase the yield of hydrogen cyanide (i.e. the amount present at equilibrium) without decreasing the rate at which the hydrogen cyanide is produced. Explain your answer.

increase temp

keep no rate high

system favour endo

∴ HCN yield will increase

(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.

$$\therefore \; n(C) = \frac{1.715}{44.01} = 0.0389... \qquad \therefore mass = 0.46801$$

$$n(N) = \frac{0.2521}{46.01} = 0.005479. \quad \therefore mass = 0.0767635$$

$$n(H_2O) = \frac{0.2521}{18.016} = 0.0139931$$

$$n(H) = 0.0139931 \times 2 \qquad \therefore mass\, H = 0.02821$$
$$= 0.0279862$$

$$n\, S) = \frac{0.3568}{64.06} = 0.0055697 \quad \therefore mass = 0.179545$$

$$m(O) = 1.021 - \left(0.46801 + 0.076735 + 0.02821 + 0.179545 \right)$$
$$= 0.278045$$

$$\therefore n(O) = \frac{0.278045}{16} = 0.0173778$$

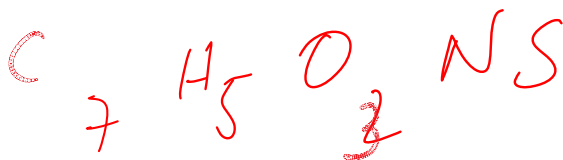| C	:	H	:	O	:	N	:	S
0.0399		0.027898		0.0173778		0.0054..		0.0055697
7.2		5.16		3		1		1

$$C_7 H_5 O_3 NS$$

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.

$$Fe_2O_{3\ (s)} + 3\ CO_{(g)} \rightarrow 2Fe_{(l)} + 3\ CO_{2\ (g)}$$

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

i) reaction occurs at high temperatures

increase #, energy and frequency in collisions ∴ ↑ rxn rate.

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

reactants continually added. product continually removed

b) If 1.00 tonne of iron ore containing 96.5% iron (III) oxide is fed into the blast furnace with 2.70 x 10⁶ L of carbon monoxide gas at 1.12 atm of pressure and 1986°C.
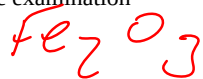
i) Determine the limiting reagent.

$$n(Fe_2O_3) = \frac{965000}{159.7}$$

$$= 6042.58.$$

$$n(CO) = \frac{PV}{RT} = \frac{113.456(2700000)}{8.315\ (2259.1)}$$

$$= 16307$$

96.5% of
1 tonne
= 965000 g.

$$Fe_2O_3 \qquad : \qquad \boxed{CO} \text{ is } LR,$$

$$SR \qquad \frac{1}{} \qquad : \qquad \frac{3}{}$$

$$6042 \qquad 16\,307$$

$$1 \qquad : \qquad 2.69 \qquad \frac{1}{3}$$

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

$$CO \quad : \quad Fe$$
$$3 \quad : \quad 2$$
$$16\,307 \quad : \quad 10\,871.333$$

$$\therefore \text{mass } (Fe) = 607 \text{ kg}$$

iii) Calculate the mass of excess reactant.

$$\text{excess } Fe_2O_3 = n(Fe_2O_3)_{initial} - n(Fe_2O_3)_{used}$$

$$= 6042 - 5435.67$$

$$= 606.33$$

$$mass \; Fe_2O_3 = 96.8 \text{ kg}$$

iv) If 5.56 x 10⁻¹ tonne of iron is produced then determine the percentage yield of the process.
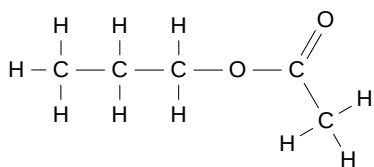
$$actual \quad - \quad \frac{556}{607} \times 100 = 91.6\%$$

$$\downarrow$$
theoretical value

3.   (11 marks)

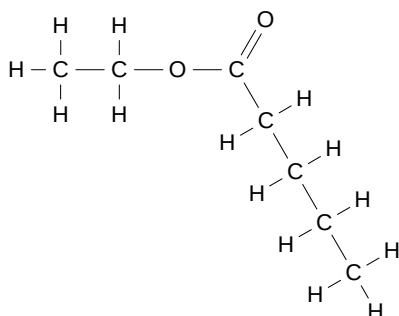An industrial chemist is working with esters to create a fruity smelling shampoo.

Propylethanoate smells of pears and has the structure;

$M_R = 102.13$

$5 : 10$

Ethylpentanoate smells of apples and has the structure;

$M_R = 130.102$

$7 : 14$

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_2 and 3.30 g H_2O on combustion. Determine which ester she has identified.

$$n(C) = \frac{8.06}{44.01} = 0.1831401$$

$$\therefore mass\ C = 2.1995$$

$$\therefore \%\ C\ in\ sample = \frac{2.1995 \times 100}{3.40} = 64.7\%$$

SAMPLE A $= \dfrac{60.05}{102.13} = 58.8\%$

SAMPLE B $= \dfrac{84.02}{130.102} \times 100 = 64.6\%$
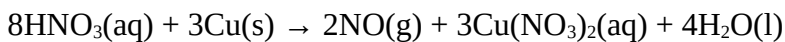
ethyl pentanoate

1

1   1   ethyl pentanoate

4.   (9 marks)

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

$$8HNO_3(aq) + 3Cu(s) \rightarrow 2NO(g) + 3Cu(NO_3)_2(aq) + 4H_2O(l)$$

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

a) $n\left(Cu\right) = \dfrac{1.037}{63.55} = 0.0163178$

$n\left(HNO_3\right) = cV = 0.025 \times 8 = 0.2$

HNO_3 : $\boxed{Cu}$ - LR

SR   8   : 3

AR   0.2   : 0.0163178

         12   ;   1

b) Cu : NO
        3   :   2
      0.0163170 : 0.0108785

PV = nRT

V = n\dfrac{RT}{p}

V = \dfrac{0.0108785\,(8.315)\,303.1}{125}

V = 219 mls

c) exess = initial - used
        = 0.2 - 0.0435141
        = 0.156

5.   (8 marks)

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

Gas	Quantity (mol)
CH_4	2.00
H_2O	1.25
CO	0.75
H_2	0.75

The following reaction is occurring:

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H = +206 \text{ kJ}$$
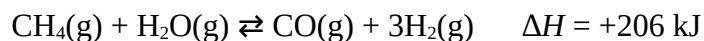
The equilibrium constant, K, is 0.26 at 730.0°C.

a)   Write the equilibrium constant expression for the reaction.

$$K = \frac{[H_2]^3 [CO]}{[CH_4][H_2O]} \qquad @ \ 730°C$$

b)   Determine whether the system is at equilibrium.

$$K = \frac{[0.75]^3[0.75]}{[1.25](2)} \qquad = \frac{0.3164062}{2.5} = 0.1265624$$

NO

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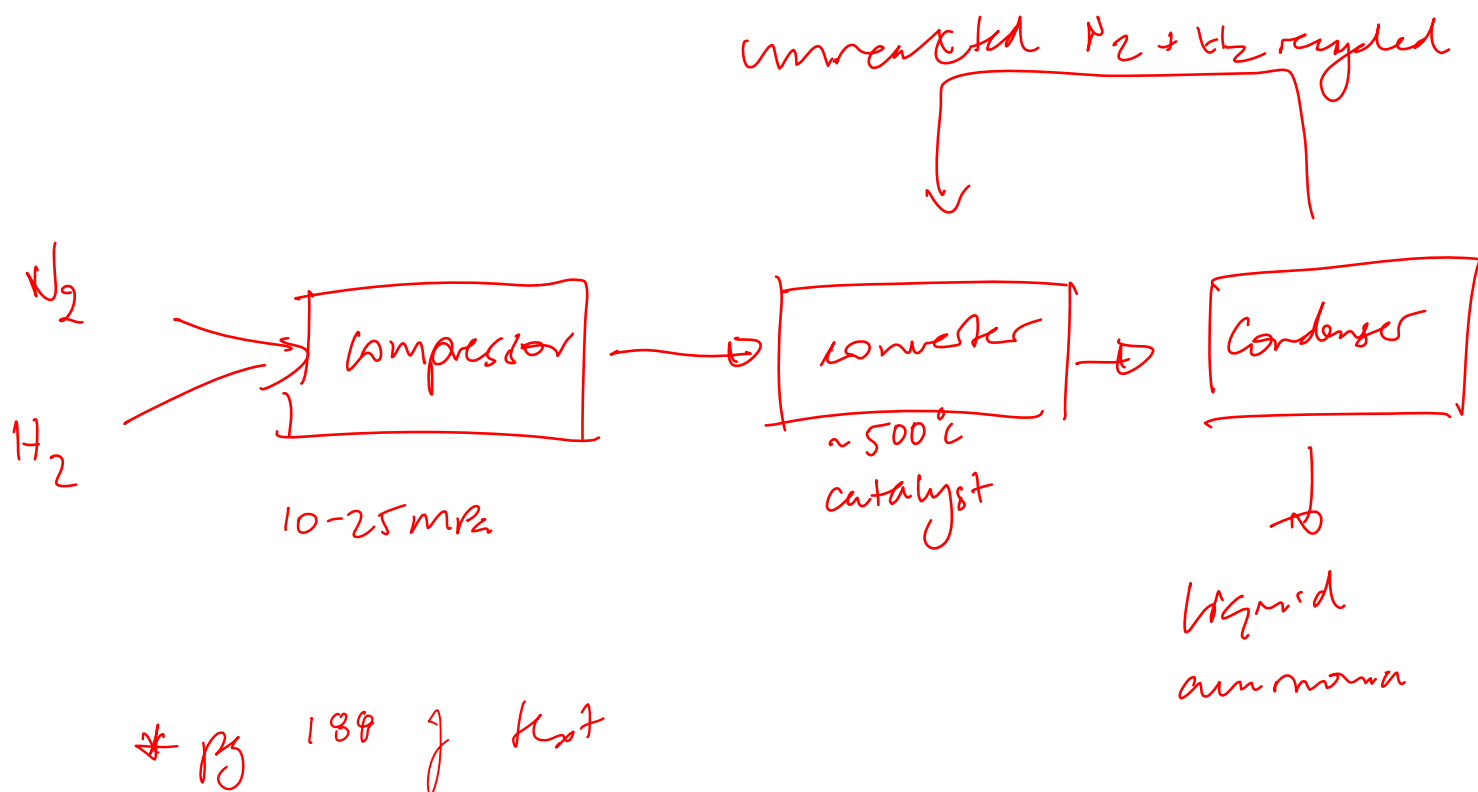
↑ temp

decrease

pressure

6.   (12 marks)

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

a)   Write an equation to represent the Haber process.

$$N_2 (g) + 3H_2 (g) \longrightarrow 2NH_3 (g)$$

b)   Draw a flowchart for the Haber process.

unreacted $N_2 + H_2$ recycled

N_2

H_2

| Compressor |

10-25 MPa

| Converter |

~500°C
catalyst

| Condenser |

liquid
ammonia

* β 188 J heat

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.

high temp favours fast rxn
but not yield of product.

i. moderate temp is chosen ∵ high pressure

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

Fe - fast reaction
  - less energy req.
  - more cost efficient.

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

10 - 25 MPa

favours forward

high pressure

reaction less is formed
       co   gas

Counteracting   increased pressure.
the

i. improves yield.

END OF PART 3

END OF EXAMINATION