Number_____

Pymble Ladies' College

Chemistry

2003
Trial Examination

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board-approved calculators may be used
- Write using black or blue pen

Section I Total marks **(75)**
This section has two parts, Part A and Part B

Part A Multiple choice Total marks **(15)**
- Attempt Questions 1–15

Part B Extended Answers Total marks **(60)**
- Attempt Questions 16–28

Section II Total marks **(25)**
- Attempt ONE question - Question 29

A Periodic Table and Data Sheet are provided as a pull-off sheet at the back of this paper.

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Section I – Part A

1. While studying for an examination, a student came across the following quotes on the internet concerning anodes and cathodes.

Which of the following is the correct quote for her to learn?

A. The anode in a galvanic cell is where oxidation occurs while an electrolytic cell has oxidation at the cathode.
B. The anode in a galvanic cell is where reduction occurs while an electrolytic cell has reduction at the cathode.
C. The anode in a galvanic cell is where oxidation occurs and an electrolytic cell also has oxidation at the anode.
D. The anode in a galvanic cell is where reduction occurs and an electrolytic cell has oxidation at the anode.

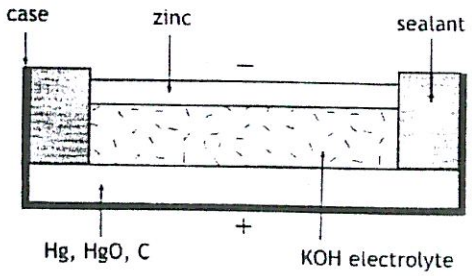
2. In comparing ethane and ethene, which of the following statements is correct?

A. Ethane has a higher melting point due to the weaker dispersion forces between ethane molecules.
B. Ethane is less reactive than ethene and ethane undergoes substitution reactions.
C. Ethane and ethene are both polar molecules.
D. Ethane is less reactive then ethene and undergoes addition reactions.

3. The stability of isotopes is related to the ratio of neutrons to protons in the nucleus. Unstable nuclei elements with:

A. a low atomic number mainly produce β-particles.
B. an atomic number greater than 83 produce α-particles only.
C. an atomic number less than 83 produce α-particles and γ-radiation only.
D. a neutron to proton ratio between 1 and 1.1 produce γ-radiation only.

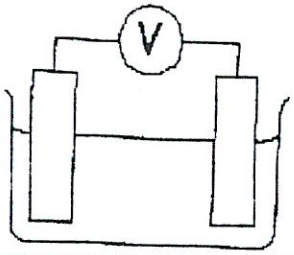
4. The diagram below is of Mercury Cell (a primary cell).



Choose the correct statement.

A. The oxidation process is $HgO + 2\ OH^- + 2e^- \longrightarrow Hg + 2\ OH^-$.
B. The cell reaction is $Zn_{(s)} + HgO_{(s)} \longrightarrow ZnO_{(s)} + Hg_{(s)}$
C. The HgO is the anode.
D. The electrolyte is liquid mercury.

5. The diagram represents a simple galvanic cell in which two metals are placed in a liquid. The metals are connected by a voltmeter. Which of the following combinations would give the highest voltmeter reading?



	METAL 1	METAL 2	LIQUID
A.	silver	copper	water
B.	magnesium	lead	ethanol
C.	zinc	tin	hydrochloric acid
D.	copper	copper	copper sulfate solution

6. Esters are often used as food additives. They are formed from the reaction of a carboxylic acid and an alcohol. What is the IUPAC name of the following ester?

$CH_3CH_2CH_2CH_2OOCCH_3$

A. ethyl butanoate
B. propyl butanoate
C. butyl ethanoate
D. methyl pentanoate

7. Sulfuric acid dissociates completely in water. The pH of a 0.0005 mol L^{-1} solution of sulfuric acid in water is

A. 3.0
B. 3.3
C. 11
D. 10.7

8. Antacid tablets are used to counteract excess stomach acidity. The substance that would be most unsuitable for this purpose would be

A. sodium hydroxide
B. aluminium hydroxide
C. magnesium hydroxide
D. sodium hydrogen carbonate.

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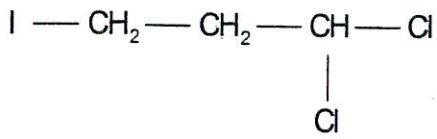
9. Excess hydrochloric acid was added to a mixture of sodium carbonate and sodium hydrogen carbonate. 1.0 mol of carbon dioxide was formed. The mixture could have contained:

A. 0.25 mol $NaHCO_3$ and 0.25 mol Na_2CO_3
B. 0.50 mol $NaHCO_3$ and 1.0 mol Na_2CO_3
C. 0.50 mol $NaHCO_3$ and 0.50 mol Na_2CO_3
D. 0.50 mol $NaHCO_3$ and 0.25 mol Na_2CO_3

$3HCl + Na_2CO_3 + NaHCO_3 \rightarrow 2CO_2 + 2H_2O + 3NaCl$

10. What is the IUPAC name for this molecule?

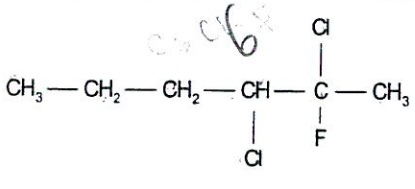


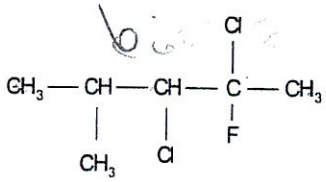
A. 3-iodo-1,1-dichloropropane
B. 1-iodo-dichloropropane
C. 1-iodo-3,3-dichloropropane
D. 1,1-dichloro-3-iodopropane

Cl more EN

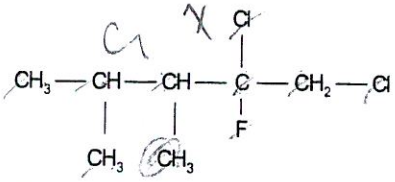
11. Which of the following is NOT a pair of isomers?

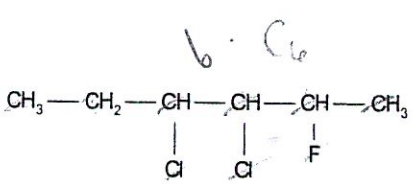
A.



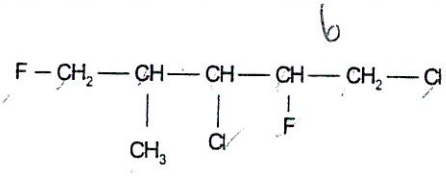


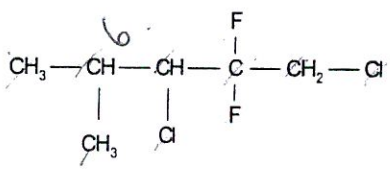
B.



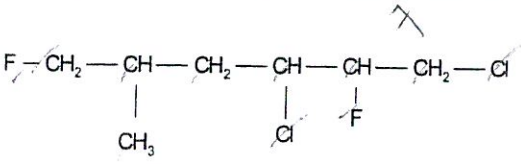


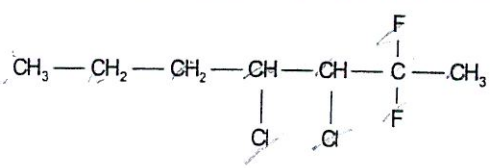
C.





D.





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12. Which equation represents the formation of ammonia?

A. $N_{2(g)} + 3\ H_{2(g)} \longleftrightarrow 2\ NH_{3(g)}$

B. $2\ N_{(g)} + 3\ H_{2(g)} \longleftrightarrow 2\ NH_{3(g)}$

C. $N_{2(g)} + 3\ H_{2(g)} \longleftrightarrow 2\ NH_{3(l)}$

D. $N_{2(g)} + 4\ H_{2(g)} \longleftrightarrow 2\ NH_{4}^{+}{}_{(g)}$

13. What technique is most likely to be used to determine the concentration of metal ions in a solution?

A. gravimetric analysis
B. titration
C. Atomic Absorption spectroscopy
D. chromatography

14. What test would provide information about whether a sample contained lead ions?

A. flame test
B. addition of silver nitrate
C. addition of sodium hydroxide
D. litmus test

15. Which layer of the atmosphere contains ozone in the highest concentration?

A. Troposphere
B. Stratosphere
C. Thermosphere
D. Mesosphere

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Section I – Part B
Total marks (60)
Attempt questions 16 – 28

Answer the questions in the spaces provided

Question 16 (5 marks)
Polystyrene is a widely used polymer.

a) Identify the systematic name of the monomer used to manufacture this polymer.

ethlyn ethenyl benzen

phenyl ethylene ✓ @ 1

1

b) Identify ONE use of this polymer and describe its use in terms of its properties.

Used as foam ✓ cups - it is soft ✓ and not very dense

easily moulded /

2

c) Explain why the recycling of plastics is an important means of conserving our fossil fuel reserves.

Plastics are produced from fossil fuel constituents. However fossil fuels are ✓ running out so we need ✓ to recycle plastics so that fossil fuels can ✓ be used as other fuels. The making of plastics from fossil fuels is quite abundant, so by recycling we can save fossil fuels (which are non renewable) 2

2

Question 17 (4 marks)

a) The radioisotope $^{244}_{94}Pu$ can be used as a nuclear fuel. What is meant by the term radio-isotope?

Radio isotope is a radioactive isotope ; that is it has an unstable nuclei and releases radiation ✓ /

1

b) High concentration of caesium-137 was found over much of Europe after the Chernobyl nuclear power plant explosion. Write a balanced nuclear equation for the Beta decay of Caesium-137.

$^{137}_{55}Cs \rightarrow {}^{0}_{-1}e + {}^{137}_{56}Ba$ ✓ /

1

c) Name and describe the use of one radioisotope, other than plutonium, that is used in industry.

Na - 24 ✓ is used to detect leaks in pipes. It is mixed with solution and poured into the pipe. Handheld detectors are held around the pipe to detect radiation. Since the radiation can only penetrate if there's a leak, it detects leaks. It has a short half life of 15 hrs so is good. 2

2

7

87

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Question 18 (5 marks)

Cellulose is an example of a condensation polymer that is found in plant material.

a) Explain what is meant by a condensation polymer.

A polymer that is produced from ——— monomers and does not contain all atoms, i.e. a small molecule (such as H_2O) is produced as well. 1

b) Discuss the potential of cellulose as a raw material to reduce our dependence on fossil fuels.

Cellulose contains the C-C structure bonds that are found in fossil fuels. This is something useable. Also, cellulose comes from biomass which is a renewable source However the amount of energy required to break up the biopolymer into useful products (such as glucose) is not viable and the cost to do so is too expensive compared to the produce. Studies are now conducted to find an efficient catalyst so that the use of cellulose as a raw material is more viable. 4

Question 19 (4 marks)

A student prepared 0.1 M solutions of two different acids, citric (2-hydroxypropane-1,2,3-tricarboxylic acid) and hydrochloric acid.

a) Compare the relative strengths of these acids.

Hydrochloric acid is a strong acid and citric acid is weaker than hydrochloric acid. 1

b) Explain, using the relevant equations, why the pH of these acids would differ, despite the fact that they are the same concentration.

As HCl is strong it will fully dissociate However it is monoprotic so will only have one H^+ per HCl.

$$HCl_{(aq)} \longrightarrow H^+_{(aq)} + Cl^-_{(aq)}$$

Citric acid is triprotic and so will dissociate to produce $3H^+$, but as it is a weak acid will only partially dissociate.

$$H_3Cit_{(aq)} \rightleftharpoons 3H^+_{(aq)} + Cit^{3-}_{(aq)}$$

Therefore even though they are the same concentration, the conc of dissociate H^+ is different. As $pH = -\log_{10}[H^+]$ therefore pH would differ. 3

good

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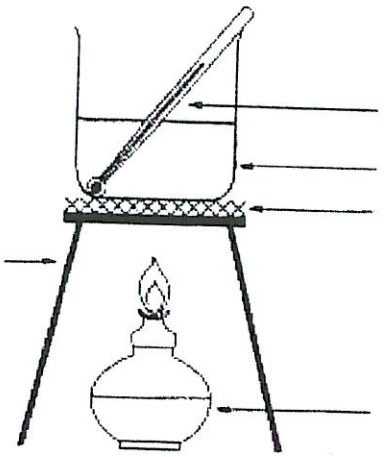
Question 20 (8 marks)

Ethanol is readily available from renewable resources such as plants.
Students were asked to perform a first hand investigation to determine the molar heat of combustion of 1-propanol and compare it to that of ethanol.

The following extract is from the practical report of their experiment.

Apparatus used:



Lab Data	
Mass of water =	250.0 g
Initial mass of burner =	221.4 g
Final mass of burner =	219.1 g
Initial temperature of water =	19.0°C
Final temperature of water =	59.0°C

a) The students forgot to prepare a risk assessment for this task. Outline an appropriate risk assessment for this practical.

Wear safety glasses, and gloves.
Risk: Boiling water / flame
What to do: Wear safety glasses to avoid splashing and gloves so don't get burnt from flame. 2

2

b) Propose TWO adjustments that could be made to the apparatus or experimental method to improve the accuracy of the experiment.

① Don't use gauze mat as this will absorb some of the heat from the spirit burner. Instead use a clamp and retort stand.

② Repeat measurements of all data to minimise parallax error / human error and improve accuracy by taking the average.

2

- Replace glass pentic with metal 9
- Put in fume to transfer heat directly
- Place thermometer into mid air

3

c) Calculate the molar heat of combustion of 1-propanol. C_3H_7OH

-ve $q = mC\Delta T$

Sig fig $= (250)(4.18)(59 - 19)$

$= 41800$

-ve $\Rightarrow$ exothermic $\Delta H = \frac{q}{n}$

$= \frac{41800}{0.03827...}$

$= 1092143\ J\,mol^{-1}$

$\approx 1092\ kJ\,mol^{-1}$ (4 sf)

$n = \frac{m}{mm}$

$= \frac{(221.4 - 219.1)}{3(12.01) + 8(1.008) + 16}$

$= 0.03827...$

3

d) The value for the molar heat of combustion for ethanol in the data books is 1364 kJ mol^{-1} and that for 1-propanol is 2016 kJ mol^{-1}. Suggest one reason that your results might differ from that of the data books.

heat loss to surroundings ∴ smaller molar heat of combustion experimentally than theoretically

heat is absorbed by beaker, air around beaker, gauze mat...

1

Question 21 (3 marks)

A solution of potassium hydrogen carbonate is basic while a solution of ammonium nitrate is acidic.

a) Write an equation to show how the potassium hydrogen carbonate reacts with water to produce a basic solution.

$KHCO_3(aq) + H_2O(l) \rightarrow K^+(aq) + H_2CO_3(aq) + OH^-(aq)$??

1

b) Identify the acid base conjugate pairs when ammonium nitrate dissolves in water.

$NH_4NO_3(aq) + H_2O(l) \rightarrow NH_3(aq) + H_3O^+(aq) + NO_3^-(aq)$

Acid / base conjugate: NH_4^+ / NH_3

Base / acid conjugate: H_2O / H_3O^+

2

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Question 22 (6 marks)

A student performed a first hand investigation to decarbonate soft drink. She did this by firstly weighing the unopened bottle of drink. She then released the lid of the drink, allowing as much gas to escape as possible. She then gently warmed the drink for 20 minutes on a hot plate. Cooled the bottle and then reweighed it. She repeated this several times. The total loss of weight from the 500mL bottle of drink was 3.5g.

a) What volume would this amount of carbon dioxide occupy at 100 kPa and 25° C?

24.79

$V = nV_m$

$n = \frac{3.5}{44} \times 24.79 = V$

$n(CO_2) = \frac{3.5}{12.01 + 2(16)}$

$= 0.0795...$

$n(CO_2) = \frac{V(CO_2)}{24.79}$

$V(CO_2) = 1.971... L$

$\approx 2.0 L$ (2sf)

2

b) The solubility of carbon dioxide in water varies with temperature and pressure. Explain how this variation occurs using Le Chateliers principle.

$CO_{2(g)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)}$ ← 이쪽으로 기울어지면 Solubility incr.

As temperature increases, solubicity of CO_2 decreases since the above reaction is exothermic. According to Le Chateliers Principle which states when a constraint (change) is put on a system, the equilibrium system will move is such a way as to minimise the constraint, ~~Thus~~ when temp. increases, the endothermic side is favored (reverse reaction above), and so solubility decreases. When pressure increases, the side with less gaseous molecules is favored (by Le Chatelier's Principle), thus the solubility increases. Similarly if pressure decreases, solubility decreases.

Also, if temp decreases, Solubility increases.

4

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Question 23 (3 marks)

There are many species which we say are amphiprotic. From the list below identify ONE amphiprotic species and construct equations to demonstrate the behaviour of this amphiprotic species in acidic and in basic solutions.

NH_4^+ H_2O NH_3 HCO_3^- SO_4^{2-}

acting as ACID: $HCO_3^-(aq) + H_2O(l) \rightarrow H_3O^+ + CO_3^{2-}(aq)$

in base soln: $HCO_3^-(aq) + NaOH(aq) \rightarrow CO_3^{2-}(aq) + Na^+(aq) + H_2O(l)$

acting as BASE: $HCO_3^-(aq) + H_2O(l) \rightarrow H_2CO_3(aq) + OH^-(aq)$

in acid soln: $HCO_3^-(aq) + HCl(aq) \rightarrow H_2CO_3(aq) + Cl^-(aq)$

$HCO_3^-(aq) + HCl(aq) \rightarrow H_2O(l) + CO_2(g) + Cl^-(aq)$

3

Question 24 (3 marks)

Some reactions need to be monitored because they form different products under different conditions.

a) Write TWO equations to show that the products of combustion vary depending on how much oxygen is available.

Complete
In sufficient oxygen: $C_2H_6(g) + \frac{7}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

Incomplete
Not enough oxygen: $C_2H_6(g) + \frac{3}{2}O_2(g) \rightarrow 2C(g) + 3H_2O(l)$

2

b) Why is it important to monitor this reaction?

The carbon soot or carbon monoxide produced from incomplete combustion is a major form of pollution and carbon monoxide is dangerous / lawful to humans.

1

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Question 25 (8 marks)

The concentration of acid in many common household substances is calculated using the technique of titration. A standard solution is prepared and the concentration of the unknown substances is determined using this standard solution. Sodium carbonate is often used as a primary standard.

a) Identify the properties required for a substance to be considered a Primary Standard.

Anhydrous, relatively unreactive, large molecular mass, ~~is~~ soluble in water.

1

b) Describe the correct technique for preparing a standard sodium carbonate solution.

Place known mass of Na_2CO_3 in a volumetric flask (100mL). Pour about 20mL of distilled water and

① Place known mass of Na_2CO_3 in a beaker (50mL)

② Pour distilled water into beaker (≈ 25mL)

③ Mix with sting rod to make sure the Na_2CO_3 dissolves

~~④ Pour this solution~~

3

④ Pour this solution into a volumetric flask (100mL)

⑤ Rinse the beaker with distilled water (≈ 5mL)

⑥ Repeat ⑤ until all the solution is completely in the volumetric flask.

⑦ Fill the volumetric flask up to 95mL

⑧ Using an eyedropper, fill the volumetric flask up to 100mL carefully.

⑨ Invert the volumetric flask (put lid on before you do this)

3

c) 2.65 g of sodium carbonate is used to make a standard solution by dissolving it in 250ml of water. This was then used to titrate 25 mL of a solution of vinegar so that its concentration of acetic (ethanoic) acid can be calculated. The titration was repeated until all values agreed within 0.05 mL. The results are shown below. Use these to calculate the concentration of the acetic acid in the vinegar solution.

RUN	ACID TITRE (mL)
Rough	25.80
1	25.60
2	25.55
3	25.65

} 25.6.

$Na_2CO_{3(aq)} + 2C_2H_5COOH_{(aq)} \rightarrow C_2H_5COONa_{(aq)} + H_2O_{(l)} + CO_{2(g)}$

equation ✓1.

find n of known of known

find c of above

Find n of acid using 25m

$n(Na_2CO_3) = \frac{m}{mm}$

$= \frac{2.65}{2(22.99) + 12.01 + 3(16)}$

$= 0.025\ 002\ 3\ldots$ moles

$C(Na_2CO_3) = \frac{n}{V}$

Find conc. by using titre

$= 0.1000\ldots$ M

4

$n_{25}(Na_2CO_3) = C \cdot V$

$= (0.1000\ldots)(25 \times 10^{-3})$

$= 2.500\ 23\ldots \times 10^{-3}$ moles

$n(C_2H_5COOH) = 2n_{25}(Na_2CO_3)$

$= 2(2.500\ 23\ldots \times 10^{-3})$

$= 5.000\ 47\ldots \times 10^{-3}$ moles

4

$C(C_2H_5COOH) = \frac{n}{V}$

$= \frac{5.000\ 47\ldots \times 10^{-3}}{(25.6 + 25.55 + 25.65) \times 10^{-3}}$

$= 0.1952\ldots$ M

≈ 0.20 M (2 s.f.)

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Question 26 (2 marks)

a) Some of the properties of Ozone and Oxygen are tabulated below.

Property	Ozone	Oxygen
Boiling point	- 193 °C	-111°C
Density	Slightly denser than air	1.5 times denser than air
Reactivity	Highly reactive	reactive
Colour	blue	colourless

bonding energy ↓ (↓) simple bond is weaker than double bond.

Choose ONE of these properties and account for it in terms of the molecular structure and the bonding of the molecule.

oxygen O=O, ozone O=O⁺-O⁻

Oxygen is less reactive than ozone.

As ozone has a coordinate covalent bond, it is slightly polar - this makes it reactive as it can attract charged particles. Oxygen, however has a double covalent bond only which makes it a non polar molecule, thus less reactive than ozone.

+1

2

Question 27 (4 marks)

a) Lawn food contains sulfate ions. Explain the chemistry involved in the experiment you did to measure the sulfate content of lawn fertiliser.

The fertiliser was dissolved in water, then HCl (to make sure all the sulfate dissolved), then reacted with Ba^{2+}; $Ba^{2+}_{(aq)} + SO_4^{2-}_{(aq)} \rightarrow BaSO_{4(s)}$. The precipitate was weighed to determine the amount of sulfate.

The chemistry involved was based on solubility of sulfate.

2

2

b) When a student performed the above experiment, they found the barium sulfate precipitate weighed 2.2 grams. Calculate the mass of the sulfate in the lawn food.

Assume $m(SO_4^{2-}) = m(SO_4)$(

$n(BaSO_4) = \frac{m}{mm}$

$= \frac{2.2}{(137.3 + 4(16) + 32.07)}$

$= 9.427 \times 10^{-3}$ moles

$n(SO_4^{2-}) = n(BaSO_4)$

$= 9.427 \times 10^{-3}$ moles

$m(SO_4^{2-}) = n \times mm$

$= (9.427 \times 10^{-3}) \times (4(16) + 32.07)$

$= 0.9056$ g

≈ 0.91 g (2 s.f.)

2

4 5

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Question 28 (5 marks)

In your studies you have investigated the endothermic esterification reaction and the exothermic reaction which produces ammonia using the Haber process. Compare these processes in terms of reaction rate and equilibrium.

With esterification:

$R_a-OH + R_b-COOH \rightleftharpoons R_a-COO-R_b + H_2O$

alcohol + alkanoic acid ⇌ ester + water

This is an endothermic reaction. When the temperature increases, the foward reaction is favoured and thus the yield of products (ester) increases (eq'm shifts right). Also, by increasing temperature, the reactats have more kinetic energy which means the reaction rate increases. Therefore forward reaction is proportional to reaction rate.

With Haber process:

$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

This is an exothermic reaction. When the temperature decreases, the forward reaction is favoured (by Le Chatelier's Principle which states when a constraint is placed on the eq'm system, the system will move in such a way as to minimise the constraint). However, when temperature decreases, the molecules have less kinetic energy and so the nuber of successful collisions decrease, therefore the reaction rate decreases. Thus unlike esterification, by altering temperature to favour forward reaction, the reaction rate decreases.

5

Similarities: when temp increases, reaction rate increases,

Differences: for esterification, the reaction rate and forward reaction are proportional.

for Haber process, the reaction rate and forward reaction are not proportional ∴ optimum temp needed

(this delicate balance between rate of reaction and temp of reaction is needed)