

CHEMISTRY Higher level Paper 3 Preliminary Examinations

Wednesday 2 September 2020

1 hour 15 minutes

Class:

INSTRUCTIONS TO CANDIDATES

- Write your name, class and index number in the blanks below.
- Do not open this examination paper until instructed to do so.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for this examination paper is [45 marks].

Section A	Questions
Answer all the questions.	1 — 2

Section B	Questions
Answer all of the questions from one of the options	
Option D — Medicinal chemistry	3 — 8

Name:

Index:



Section A

Answer **all** questions. Write your answers in the boxes provided.

- 1. The Earth's atmosphere is divided into five main layers: troposphere, stratosphere, mesosphere, thermosphere and exosphere. The oxygen and ozone in the stratosphere absorbs most of the Ultraviolet (UV) radiation and protects Earth from the harmful radiation.
- (a) Oxygen molecule dissociates as shown when it absorbs UV radiation.

 $O_2 \rightarrow O^{\bullet} + O^{\bullet}$

Formulate the chemical equation that shows the dissociation of an ozone molecule upon absorbing UV radiation. [1]

 $O_3 \rightarrow O_2 + O \bullet$

(b) The information on the type of UV radiation absorb by oxygen and ozone are shown below.

	Type of UV radiation	Wavelength/ nm
Oxygen	UV-C	200 – 280
Ozone	UV-B	280 – 315

Comment on the difference in the type of UV radiation absorbed by oxygen and ozone. [2]

Stronger O-O bond in O₂ than in ozone;

hence O₂ absorbs higher energy UV

Accept converse argument.

Max 1m if only difference bond strength is mentioned.

Some halogenated compounds will dissociate in the stratosphere to form halogen radicals. In the study of stratospheric ozone, Equivalent Stratospheric Chlorine (ESC) is used as the measure for the amount of halogens (chlorine and bromine) in the stratosphere.

The relative values of the Equivalent Stratospheric Chlorine (ESC) and the concentration of stratospheric ozone, over Antarctic and Artic from 1960 to 2040 (projected) is shown below.



Using this information, briefly describe the relationship between the concentration of (c) stratospheric ozone and ESC.

[1]

Ozone concentration decreases with increase in ESC/ Negative correlation Do Not accept inverse relationship.

The average daily temperatures of Antarctic and Artic in summer and winter are shown (d) in the below.

Season	Average daily temperature / °C		
ocason	Antarctic	Artic	
Summer	-28.2	0	
Winter	-60	-40	

From 1960 to 2010, the change in ESC over the two polar regions are fairly similar. However the change in the concentration of stratospheric ozone over the two polar regions are very different.

[1]

Suggest a reason that may have caused this difference.

Temperature difference/ Antarctic is colder/ different climate

(e) The change in the amount of UV-B radiation (280nm-320nm) reaching Earth's surface in 2008 compared to 1978 is shown below.



Comparing 1978 to 2008, the amount of UV-B radiation reaching the Earth's surface at higher latitudes and polar regions show a significant increase. However the amount of UV-B radiation that reaches the equatorial region is fairly constant.

Comment on this observation.

[1]

Ozone concentration at equatorial region is not depleted thus blocking UV radiation./ OWTTE

(f) HFCs (hydrofluorocarbons) and gaseous alkanes are described as "ozone-friendly" refrigerant gases compared to CFCs.

The Ozone Depleting Potential (ODP) and Global Warming Potential (GWP)* of CFCs, HFCs and gaseous alkanes are given in the table below.

	Ozone Depleting Potential	Global Warming Potential
	(ODP)	(GWP)*
CFCs		
CFC-11	1	5160
CFC-113	0.81	6080
HFCs		
HFC-134a	0	1360
HFC-23	0	12500
HFC-143a	0	5080
HFC-125	0	3450
Alkanes		
Ethane	0	3.0
Propane	0	3.0
Butane	0	3.0

*GWP refers to the amount of heat a gas can trap in the atmosphere compare to an equivalent amount of carbon dioxide.

(i) Explain why HFCs do **not** deplete the stratospheric ozone like the CFCs.

[1]

The C-F bonds do not break as they are stronger/ No <<halogen>> radicals are formed as the C-F bonds are stronger.

Accept comparison using BE

(ii) List one advantage and disadvantage in using gaseous alkanes as refrigerant gases over HFCs and CFCs.

[2]

Advantage:
Will not contribute much/ lesser effect on global warming.
Do not accept it is not a Greenhouse gas or it does not deplete ozone (as HFC also have this advantage).
Disadvantage: Flammable gas/ fire hazard

All data and information are cited from Hannah Ritchie (2018) - "Ozone Layer". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/ozone-layer' [Online Resource]

2. Conductometric titration can be used to determine the concentration of acids or alkalis. In such titration, the electrical conductivity of the analyte is recorded as the titre is added from the burette.

In an investigation, 25.00 cm³ of sulfuric acid is pipetted into a beaker and titrated with aqueous barium hydroxide. The electrical conductivity of the aqueous sulfuric acid, as aqueous barium hydroxide is added to it, is recorded.



Source: https://www.qsstudy.com/chemistry

The data collected is presented in the graph below.



[2]

(a) The chemical equation for the reaction between the sulfuric acid and aqueous barium hydroxide is,

 $H_2SO_4(aq) + Ba(OH)_2(aq) \rightarrow BaSO_4(s) + 2 H_2O(l)$.

Explain the trend observed for the electrical conductivity of the sulfuric acid as aqueous barium hydroxide is added to it.

Barium sulfate formed is insoluble in water thus conductivity decreases as concentration of ions (H^+ and SO_4^{2-}) decrease;

After equivalence/ endpoint, conductivity increases as excess barium hydroxide increases/ restores the conc. of ions.

(b) By drawing appropriate straight lines on the graph, deduce the volume of aqueous barium hydroxide needed to reach the equivalence point. [2]

Two intersecting linear lines; Accept range 22.00 – 23.00 cm³ Accept 1 or 2 decimal place.

(c) The concentration of the aqueous barium hydroxide used is 0.100 mol dm⁻³. Using your answer to part (b), determine the concentration of the sulfuric acid.

 $[H_2SO_4] = \frac{0.100 \times 0.0225}{0.0250} = 0.0900 \text{ mol dm}^3$ Accept range from 0.088 – 0.092 mol dm⁻³ Accept 0.09 or 0.090.

(d) List one advantage of conductometric titration.

[1]

[1]

Can be used for non acid-base/ precipitation/ weak acid-base/ redox/ complex ion titrations

Or

Can be used in titrations that where there is no suitable indicators/ end-point cannot be easily detected due to colours/ turbidity of reactions.

Or

More accurate reading than use of indicators.

Section B

Answer **all** of the questions from one of the options. Write your answers in the boxes provided.

Option D — Medicinal Chemistry

3. The properties of three analgesics are summarized below.

Drug	Strength	Acts	Addictive
А	mild	at the site of pain	no
В	strong	on brain	addictive
С	strong	on brain	very addictive

(a) Deduce which drugs could be morphine, aspirin and codeine.

[2]

Morphine: C		
Aspirin: <mark>A</mark>		
Codeine: B		

(b) List the type of reaction involved in the following conversion.

[2]

Morphine to diamorphine: condensation/ esterification/ addition-elimination

Morphine to codeine : nucleophilic substitution

(c) State one side-effect of using aspirin.

Anti-inflammatory/ antipyretic/ anticoagulant/ gastric irritation/ peptic ulcers/ OWTTE

(d) Suggest a reason why ethanoic anhydride, (CH₃CO)₂O, is used preferably over ethanoyl chloride, CH₃COCl, in the conversion of morphine to diamorphine. [1]

[1]

Toxic gas/ HCl would be produced if ethanoyl chloride is used.

(e) Explain why diamorphine has greater potency than morphine.

[2]

morphine <<has hydroxyl and>> is more polar AND diamorphine <<has an ester and>> is less polar / more lipid soluble;

crossing blood brain barrier is easier for non-polar compounds/ lipid soluble compounds

- 4. The final stage of the virus replication cycle can be targeted by antivirals. Two such drugs are oseltamivir (Tamiflu) and zanamivir (Relenza).
- (a) With reference to section 37 of the data booklet, compare and contrast the structures of oseltamivir (Tamiflu) and zanamivir (Relenza).

[2]

Compare
Amine, alkenyl, ether, carboxyamide.
Contrast
Ester, carboxyl, hydroxyl
Outline how IR spectroscopy can be used to differentiate oseltamivir (Tamiflu

(b) Outline how IR spectroscopy can be used to differentiate oseltamivir (Tamiflu) and zanamivir (Relenza). [1]

3200 -3600 cm⁻¹ due to OH/ hydroxyl in zanamivir but not in oseltamivir/ 2500 -3000 cm⁻¹ due to OH in COOH in zanamivir but not in oseltamivir

(c) Suggest a reason why zanamivir (Relenza) is **not** taken orally.

[1]

Any one of the following:

To increase bioavailability; The drug must be administered rapidly/in precise/high dosage; The drug gets absorbed by the digestive tract;

- 5. Excess stomach acid leads to medical conditions that affect many people worldwide. These conditions can be treated with several types of medical drugs.
- (a) Ranitidine (Zantac) and omeprazole (Prilosec) are drugs that inhibits stomach acid production. Outline how both drugs are able to prevent stomach acid production.

[2]

Ranitidine works as a histamine blocker; Omeprazole works as a proton pump inhibitor

(b) Antacids, which combat excess stomach acid, is an example of buffers. Many over-thecounter antacids are buffers which are capable of moderating pH in stomach, bringing relief to those who suffer from "heartburn".

Calculate the ratio of methanoate ions/methanoic acid to give a buffer of pH 4.00. The pK_a of methanoic acid is 3.75.

[2]

$$4 = 3.75 + log10 \frac{base}{acid}$$

$$0.25 = log10 \frac{base}{acid};$$

$$1.78 = \frac{base}{acid};$$

Award 2m if final answer is correct

- (c) Some antacids use metal carbonates and metal hydroxides as the active ingredients to provide relief to acid reflux.
 - (i) List one disadvantage in using metal carbonates as the active ingredient in antacid.

[1]

Causes flatulence/ bloatedness/ produce gas

Outline why a mixture of aluminium hydroxide and magnesium hydroxide is (ii) used in most antacids instead of pure aluminium hydroxide or magnesium hydroxide.

[2]

Any 2 of the following Mixture to reduce the undesirable side effects of using only one ingredient; Aluminium hydroxide causes constipation; Magnesium hydroxide has laxative effect; Magnesium hydroxide acts faster while aluminium hydroxide has a more prolonged effect.

(iii) Explain why most antacids are allowed to be sold over-the-counter without the need of prescription from doctors.

[1]

Antacids have high therapeutic index	/ therapeutic window/	toxic dose/ lethal
dose		

6. Tipranavir is a HIV protease inhibitor used for the treatment of AIDS. Its production involves the use of chiral auxiliaries.

Describe how chiral auxiliaries can be used to synthesize only the desired enantiomeric form of the drug from a non-chiral starting compound. [2]

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a chiral auxiliary is itself an enantiomer/optically active;

OR

Chiral auxiliary attaches to non-chiral compound;

creates desired stereochemical conditions for reaction / ensures only on isomer

is produced;

OR

it is bonded to the reacting molecule so that reaction forms one product;

(remove chiral auxillary) to give one enantiomer;

OR

OWTTE
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- 7. A breathalyser measures the blood alcohol content from a breath sample.
- (a) Formulate half-equations for the reactions at the anode (negative electrode) and the cathode (positive electrode) in a fuel cell breathalyser. [2]



(b) Explain how the concentration of ethanol in a sample of breath can be determined using a fuel cell breathalyser.

[2]

electrons released/current/potential/voltage is proportional to concentration of ethanol (oxidized)/ethanoic acid (formed);

current/potential/voltage is compared to a reference to determine concentration of ethanol (in breath);

- 8. Iodine-131 is an important radionuclide used in the treatment of thyroid cancer.
- (a) Formulate a balanced nuclear reaction for the decay of iodine-131 into xenon-131. [1]

(b) The half-life of iodine-131 is 8.02 days.

Using information from section 1 of the data booklet, calculate the rate constant, λ , in day⁻¹, for the decay of iodine-131. [1]

$$\lambda \left(= \frac{\ln 2}{t_{\frac{1}{2}}} = \frac{0.693}{8.02 \ day} \right) = 8.64 \times 10^{-2} / 0.0864 \ \text{wday}^{-1} \text{w}$$

(c) Calculate the time, in days, for 25% of the sample to decay.

[2]

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ALTERNATIVE 1:

«N_0 = initial amount = 100%»

N \ll 100 - 25» = 75% at time t

\ll ln\left(\frac{100}{75}\right) = 0.2877 = 0.0864t»

\ll t = \frac{0.2877}{0.0864 \text{ day}^{-1}} =» 3.33 «days»

Accept 3.3 «days»

Award [2] for correct final answer.

ALTERNATIVE 2:
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 ${}^{\text{(Nt} = N_0(0.5)^{\text{n}} \text{ where n = number of half-lives}}_{75 = 100(0.5)^{\text{n}}} \\ {}^{\text{(log}\left(\frac{75}{100}\right) = n \times \log 0.5 \right)}_{\text{(-0.125} = n(-0.301)/n = \frac{0.125}{0.301}} \\ {}^{\text{(t)}}_{\text{(t)} = \frac{0.125}{0.301} \times 8.02 = 3.33} \\ {}^{\text{(t)}}_{\text{(t)} = \frac{0.125}{0.301} \times 8.02} \\ {}^{\text{(t)}}_{\text{(t)} = \frac{$

Accept 3.3 «days» Award [2] for correct final answer.

-End of Paper-