2021 TRIAL HSC EXAMINATION

Chemistry

Section I - 20 marks

Attempt Questions 1–20 Allow about 35 minutes for this part.

Use the multiple-choice answer sheet provided in the bundle for Questions 1–20.

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1 A student was given a solution containing an unknown soluble salt. They dipped a clean metal loop into the solution and place it in a blue Bunsen burner flame. The flame went blue-green.

Which metal ion could the solution contain?

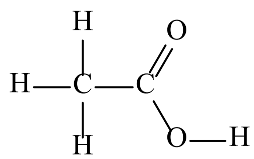
A. barium

B. calcium

C. copper

D. magnesium

2 To which homologous series does this substance belong?



A. alcohols

B. aldehydes

C. carboxylic acids

D. ketones

3 Hydrogen iodide gas decomposes according to the equation:

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g) \qquad \Delta H = +18.8 \text{ kJ mol}^{-1}$$

Identify the change to the system that will decrease the equilibrium concentration of iodine.

A. Adding a catalyst.

B. Decreasing the volume.

C. Increasing the temperature.

D. Decreasing the temperature.

4 An aqueous equilibrium between bromide and cadmium ions is shown below:

$$Cd^{2+}(aq) + 4Br^{-}(aq) \rightleftharpoons CdBr_4^{2-}(aq)$$

Identify the correct equilibrium expression for this reaction.

A. $K_{eq} = \dfrac{[CdBr_4^{2-}]}{[Cd^{2+}][Br^{-}]}$

B. $K_{eq} = \dfrac{[CdBr_4^{2-}]}{[Cd^{2+}][Br^{-}]^4}$

C. $K_{eq} = \dfrac{[Cd^{2+}][Br^{-}]^4}{[CdBr_4^{2-}]}$

D. $K_{eq} = \dfrac{[CdBr_4^{2-}]}{[Cd^{2+}][4Br^{-}]}$

5 The following reaction occurs in aqueous solution. Identify the acid reactant and its conjugate base.

$$HSO_4^{-}(aq) + N_2H_4(aq) \rightleftharpoons N_2H_5^{+}(aq) + SO_4^{2-}(aq)$$

	Acid reactant	*Conjugate base*
A.	$HSO_4^{-}{}_{(aq)}$	$SO_4^{2-}{}_{(aq)}$
B.	$HSO_4^{-}{}_{(aq)}$	$N_2H_5^{+}{}_{(aq)}$
C.	$N_2H_{4(aq)}$	$SO_4^{2-}{}_{(aq)}$
D.	$N_2H_{4(aq)}$	$N_2H_5^{+}{}_{(aq)}$

6 Which K_{eq} value indicates a reaction where the products are most favoured?

A. $K_{eq} = 13.5$

B. $K_{eq} = 0.29$

C. $K_{eq} = 6.1 \times 10^{-4}$

D. $K_{eq} = 9.8 \times 10^{-12}$

7 Identify the tertiary alcohol.

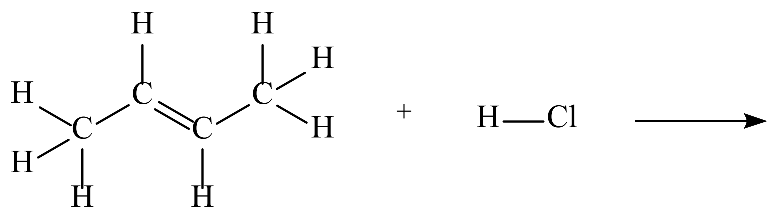
A. 3,3-dimethylbutan-1-ol

B. 3,3-dimethylbutan-2-ol

C. 2,3-dimethylbutan-1-ol

D. 2,3-dimethylbutan-2-ol

8 This question refers to the reaction below:



The systematic IUPAC name for the product of the above chemical reaction is:

A. 1-chlorobutane

B. 2-chlorobutane

C. 3-chlorobutane

D. 4-chlorobutane

9 Which statement is correct for a 0.10 $mol\,L^{-1}$ solution of the weak acid, hypochlorous acid (HOCl)?

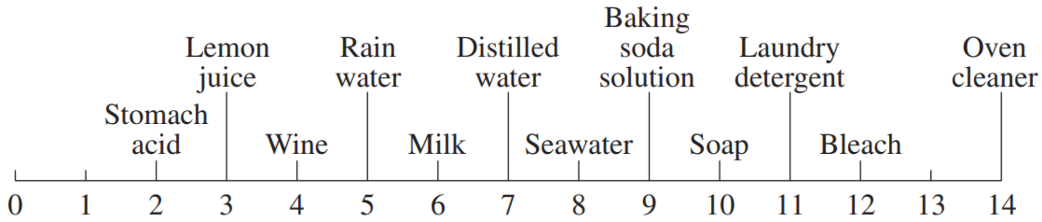
A. $[HOCl] = [H_3O^+]$

B. $[HOCl] > [H_3O^+]$

C. $[HOCl] < [H_3O^+]$

D. $[HOCl] = 0.10\ mol\,L^{-1}$

10 Based on the pH values of the common substances shown below, which statement is correct?



A. Rainwater has a hydrogen ion concentration half that of soap.

B. Wine has a hydrogen ion concentration is 1 000 times greater than distilled water.

C. Seawater has a hydrogen ion concentration is 1 000 000 times greater than stomach acid.

D. Baking soda solution has a hydrogen ion concentration three times that of lemon juice.

11 A student used indicators to determine the approximate pH of a colourless solution. The indicators used are shown in the table:

Indicator	*Colour change*	pH *range*
Thymol blue	red to yellow	1.2 – 2.8
Methyl red	red to yellow	4.2 – 6.3
Bromothymol blue	yellow to blue	6.0 – 7.6
Phenolphthalein	colourless to pink	8.3 – 10.0

The solution gave the following results:

- yellow in thymol blue
- yellow in methyl red
- blue in bromothymol blue
- colourless in phenolphthalein

What is the pH range of the solution?

A. 2.8 – 4.2

B. 6.3 – 7.6

C. 7.6 – 8.3

D. > 8.3

12 A 25.00 mL sample of 0.100 mol L^{-1} acetic acid solution needed 22.20 mL of a NaOH solution for complete neutralisation. What volume of the same NaOH solution is needed to neutralise 25.00 mL of 0.100 mol L^{-1} sulfuric acid solution?

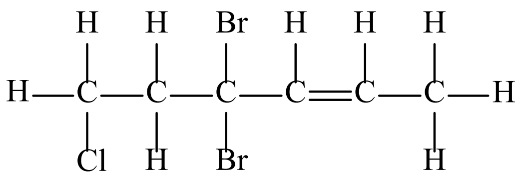
A. 11.10 mL

B. 22.20 mL

C. 33.30 mL

D. 44.40 mL

13 What is the IUPAC name of this molecule?



A. 4,4-bromo-6-chlorohex-2-ene

B. 3,3-bromo-1-chlorohex-5-ene

C. 4,4-dibromo-6-chlorohex-2-ene

D. 3,3-dibromo-1-chlorohex-5-ene

14 HI gas can be decomposed in a reaction vessel at 445°C. The equation for the reaction is shown below and the $K_{eq} = 0.020$.

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

The reaction vessel was sampled and found to contain $[HI] = 2.0$ mol L^{-1}, $[H_2] = 0.50$ mol L^{-1} and $[I_2] = 0.10$ mol L^{-1}.

Which of the following statements concerning the reaction quotient (Q_{eq}) is TRUE for this system?

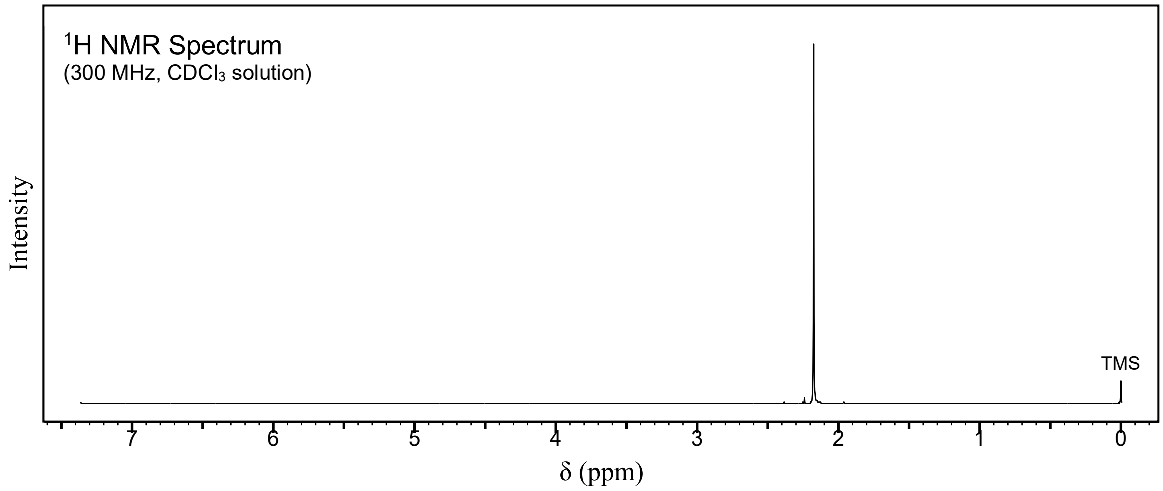
A. $Q_{eq} = K_{eq}$ and the system is at equilibrium.

B. $Q_{eq} < K_{eq}$ and more H_2 and I_2 will be produced.

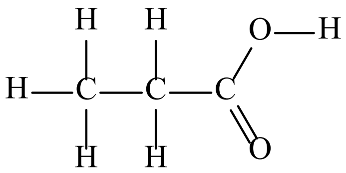
C. $Q_{eq} < K_{eq}$ and more HI will be produced.

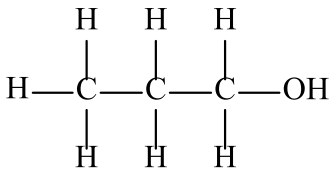
D. $Q_{eq} > K_{eq}$ and more H_2 and I_2 will be produced.

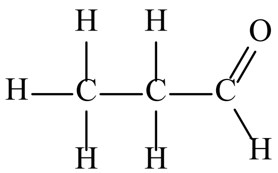
15 A molecule, C_3H_6O is analysed using nuclear magnetic resonance. The ^{1}HNMR spectrum of this molecule is shown below:

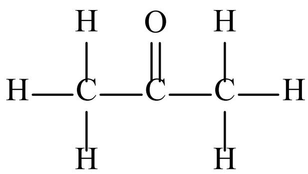


What is the structural formula of this molecule?

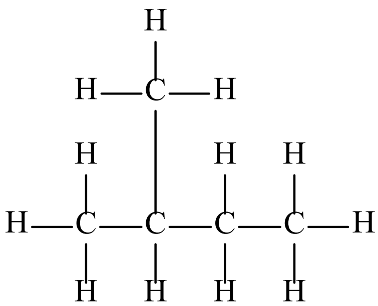
A. 

B. 

C. 

D. 

16 How many other structural chain isomers of the molecule shown exist?



A. 0

B. 1

C. 2

D. 3

17 A 0.0200 mol L^{-1} solution of a monoprotic weak acid has a pH of 3.6.

What is the K_a of this acid?

A. 2.51×10^{-4}

B. 3.15×10^{-6}

C. 3.19×10^{-6}

D. 3.13×10^{5}

18 Calculate the pH of the resulting solution when 50 mL of 0.2 M HCl is added to 50 mL of 0.1 M NaOH?

A. 1.0

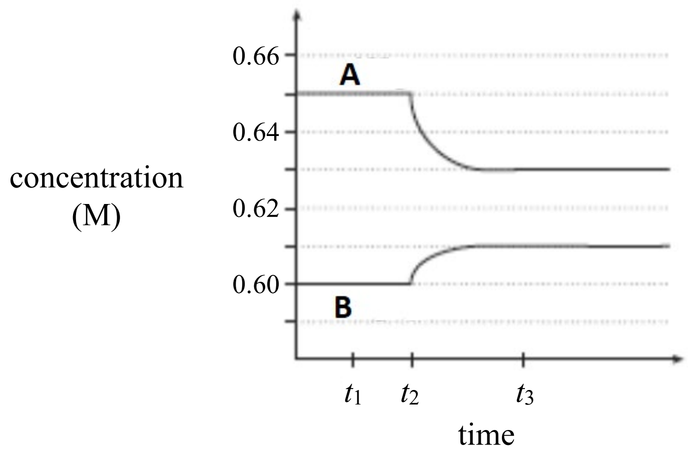
B. 1.3

C. 2.3

D. 7.0

19 Substances A and B are gases that exist in dynamic equilibrium in a sealed container.

A graph of their concentrations over time is given below:



At time t_2 the temperature was decreased. Which is correct?

A. $2A \rightleftharpoons B$ ΔH = negative

B. $2A \rightleftharpoons B$ ΔH = positive

C. $A \rightleftharpoons 2B$ ΔH = negative

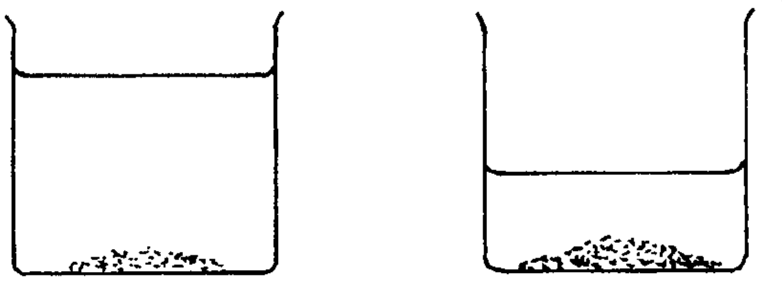
D. $A \rightleftharpoons 2B$ ΔH = positive

20 Two beakers were set up each containing 2.0 g lead(II) iodide. 200 mL of water was added to Beaker R and 100 mL of water to Beaker S. The contents of both beakers was stirred for 5 minutes and then left until the undissolved solid settled as shown below.

Both beakers were maintained at 25°C and the solubility of lead(II) iodide in water at 25°C is 0.76 g L^{-1}.

Beaker R *Beaker S*

200 mL of water



100 mL of water

2.0 g lead(II) iodide 2.0 g lead(II) iodide

Based on this information, the ratio of the concentration of lead(II) iodide solution in beaker R to the concentration of lead(II) iodide solution in beaker S is:

A. 1:1

B. 1:2

C. 2:1

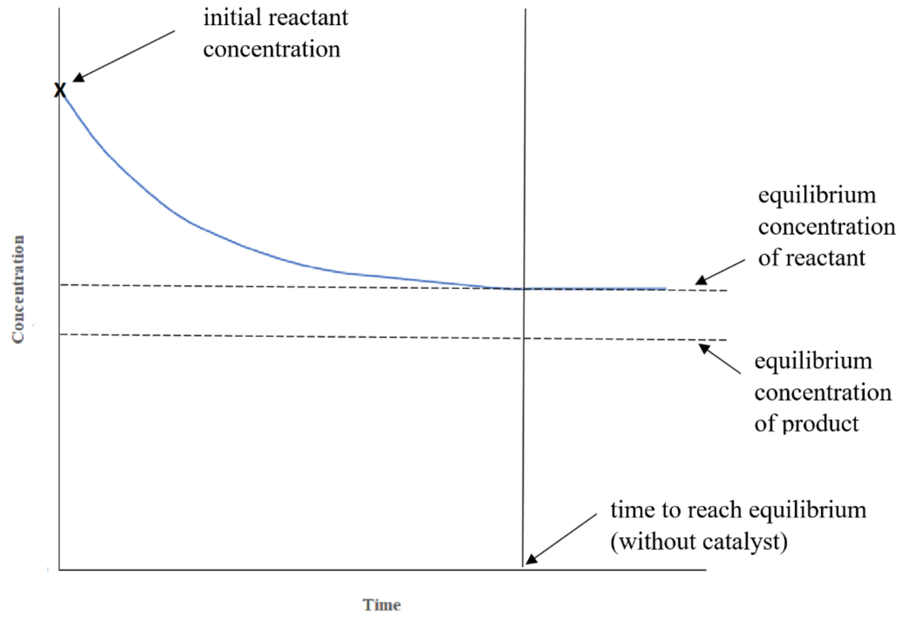
D. 1:4

Section II - 80 marks – answer all questions on the answer sheets provided

Question 21 (5 marks)

Consider the general equilibrium system:

$$\text{reactant} \rightleftharpoons \text{product}$$



(a) Complete the diagram above to show the product concentration as the system reaches and remains at equilibrium. The reactant concentration is given for you. Assume the initial product concentration is zero. **1**

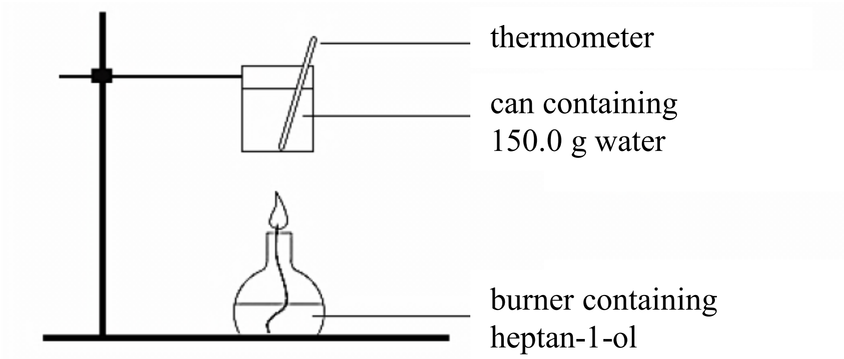
(b) On the same diagram, but using a dashed line, show the reactant and product concentrations as the system reaches and remains at equilibrium when a catalyst is present. Start at the initial concentrations. **1**

(c) Account for the difference between (a) and (b) using collision theory and rate of reaction. **3**

End of Question 21

Question 22 (5 marks)

150.0 g of water was heated in a calorimeter (as shown below) to measure the heat of combustion of heptan-1-ol. The initial temperature of the water was 20.0°C, the final temperature was 63.0°C and the mass of heptan-1-ol burnt was 0.750 g.



Use this information to answer the following questions.

(a) Write a balanced chemical equation for the complete combustion of heptan-1-ol. **1**

(b) Calculate the molar enthalpy of combustion measured for heptan-1-ol. **3**

(c) Identify one experimental error that is likely to occur in this experiment. **1**

End of Question 22

Question 23 (4 marks)

Discuss the advantages of the Brønsted-Lowry theory of acids and bases over the Arrhenius theory. Include equations and examples in your answer. **4**

End of Question 23

Question 24 (6 marks)

During a practical test, Year 12 Chemistry students were given four unknown organic chemicals (**A**, **B**, **C** and **D**) and told they were, in no particular order, cyclohexane, cyclohexene, methanol and acetic acid.

The students were given the following information.

	A	**B**	**C**	**D**
Decolourise bromine water	no	yes	no	no
Solubility in water	yes	no	no	yes

Question 24 continued

(a) Identify **B** and **C**. Justify your answer and include an equation with structural formula for the decolourisation of bromine water by **B**. **3**

(b) Describe a method, including suitable safety precautions and expected results to identify **A** and **D**. **3**

End of Question 24

Question 25 (4 marks)

The buffer system between the dihydrogen phosphate ion and the hydrogen phosphate ion is effective at maintaining intracellular pH in our bodies.

A student prepared a phosphate buffer by mixing 50 mL of 0.1M NaH_2PO_4 with 50 mL of 0.1 M Na_2HPO_4.

She tested the buffer and recorded the following results and conclusion:

Results:

	Initial pH	pH after adding a few drops of 0.1M HCl	pH after adding a few drops of 0.1M NaOH
Distilled water	7.0	3.0	11.0
Phosphate buffer	7.0	6.9	7.1

Conclusion:

The phosphate buffer prepared was effective in maintaining a pH of close to 7.

(a) Write an equation to represent this phosphate buffer system. **1**

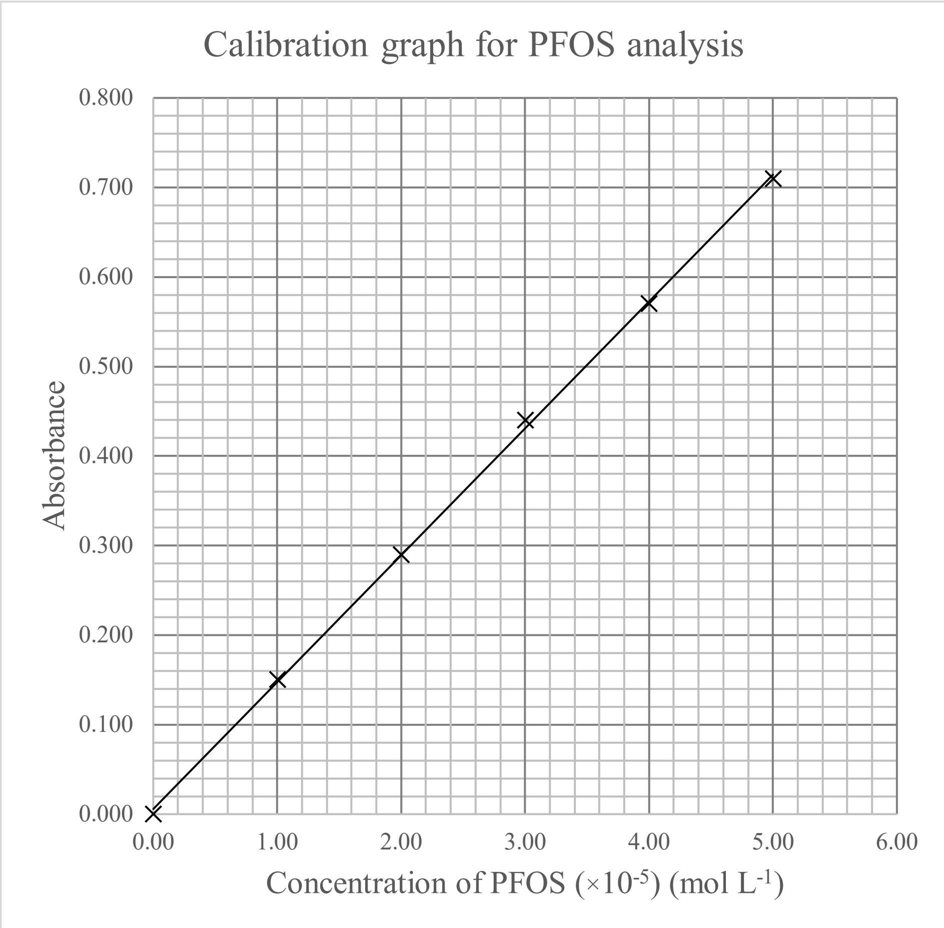
(b) Analyse the composition of the student's buffer AND explain using Le Châtelier's Principle why it was effective at maintaining the desired pH after the addition of a small volume of HCl. **3**

End of Question 25

Question 26 (6 marks)

Perfluorooctane sulfonate (PFOS) was up until recently used in fire-fighting foam. It is very stable and can persist for a long time both in the environment and in humans with detrimental effects.

The NSW EPA analyses water and soil samples near areas where PFOS has been used in large quantities. Colorimetry is used to analyse the samples as PFOS reacts with iron(III) ions in a 1:1 ratio to form a purple solution. The NSW EPA calibration graph is shown below:



To analyse soil samples, 5.00 g of soil is added to 15 mL of distilled water to dissolve the PFOS and filtered to remove particulate matter. The solution is then reacted with iron(III) ions to form a purple solution with a total volume of 50.00 mL. Exactly 10 mL of the purple solution is then pipetted into a 100 mL volumetric flask and made up to the mark with distilled water.

A soil sample was prepared using this method and the absorbance of the diluted solution was found to be **0.540**.

(a) Use the calibration graph provided to determine the concentration of PFOS in the diluted sample. Show your working on the graph. **2**

(b) Determine the concentration of PFOS in the original soil sample in % (w/w). The molar mass of PFOS is 500.158 g/mol. **4**

End of Question 26

Question 27 (5 marks)

The boiling points of some straight chain alkanes are given in the table below.

Alkane	*Formula*	*Boiling point* (°C)
methane	CH_4	− 161
ethane	C_2H_6	− 89
propane	C_3H_8	− 42
butane	C_4H_{10}	0
pentane	C_5H_{12}	36
hexane	C_6H_{12}	69
heptane	C_7H_{14}	98

(a) Explain the trend in the boiling points of these alkanes in terms of intermolecular forces. **2**

(b) Ethanol has a boiling point of 78°C. Explain why ethanol has a much higher boiling point than ethane. Include a diagram in your answer. **3**

End of Question 27

Question 28 (10 marks)

The maximum concentration of lead(II) ions (Pb^{2+}) legally permitted in the aqueous wastes of a city is 1 mg/L at 25°C. Several times a month the wastewater from a certain factory is found to exceed this limit.

The factory produces two lead compounds – lead(II) hydroxide and lead(II) carbonate but it only ever produces ONE of these compounds at a time. The factory wastewater is always a saturated solution of the lead compound being produced.

(a) Write the equilibrium expression for a saturated solution of lead(II) hydroxide. **1**

(b) Evaluate whether lead(II) hydroxide, lead(II) carbonate, or both, will cause the factory to exceed the 1 mg/L limit at 25°C. **4**

(c) To remove excess lead ions from their wastewater the factory added solid sodium sulfide so that the lead could be removed via precipitation followed by filtration.

(i) Write a balanced chemical equation for this reaction. **1**

(ii) If the factory added solid sodium sulfide to give a sulfide ion concentration in the wastewater of 5×10^{-8} mol L^{-1} and the Pb^{2+} concentration was 7×10^{-6} mol L^{-1}, would a precipitate of lead(II) sulfide form? K_{sp} (PbS) = 3.1×10^{-28} at 25°C. **2**

(d) Explain why this method of adding sodium sulfide is effective at lowering the $[Pb^{2+}]$ in the wastewater. **2**

End of question 28

Question 29 (7 marks)

Define what is meant by the term "biofuel" and discuss the use of biofuels against fossil fuels in the operation of motor vehicles. **7**

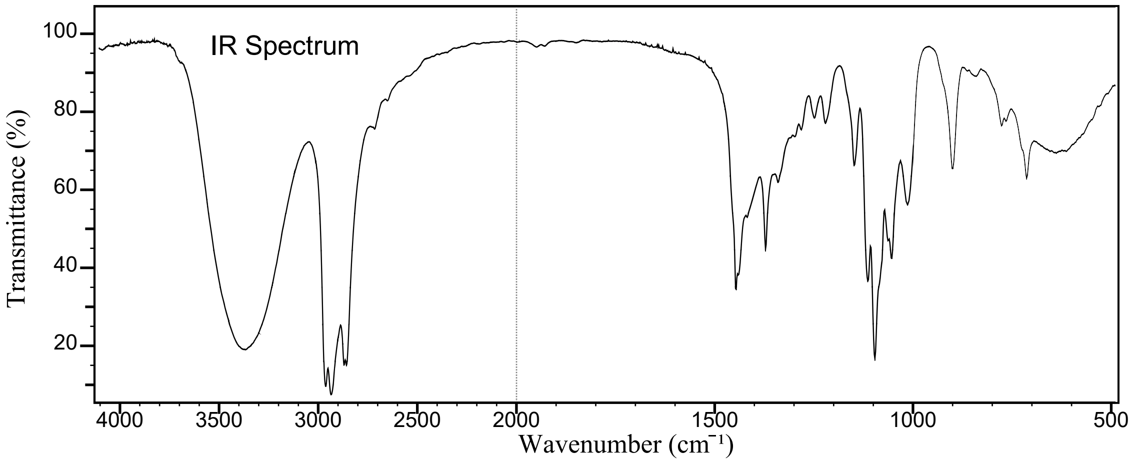
Include the following in your answer:

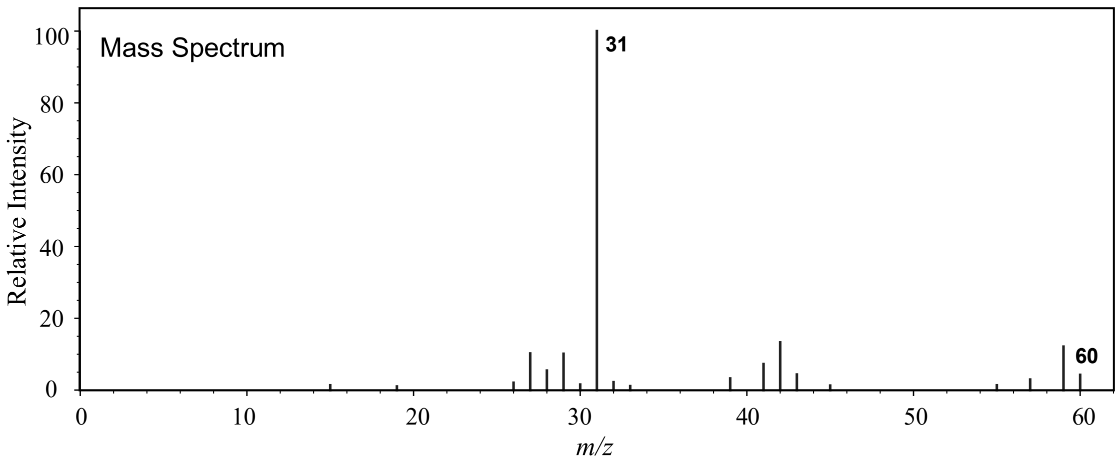
- Outline the synthesis of bioethanol.
- An equation to represent the synthesis of bioethanol.
- Equations to show the combustion of ethanol and octane.

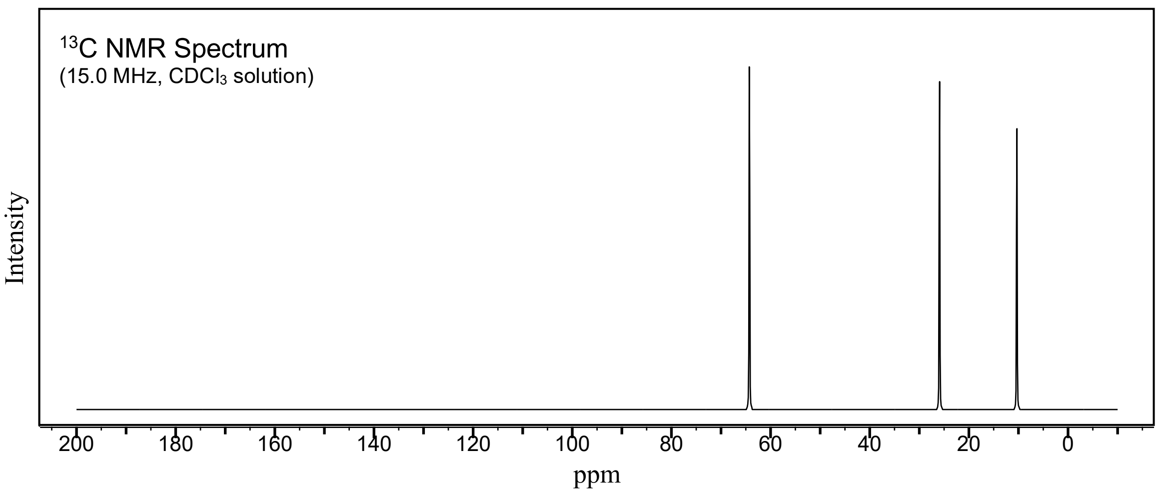
End of Question 29

Question 30 (10 marks)

The following spectra were obtained for an organic compound that contains only carbon, hydrogen and oxygen.







Question 30 continues on next page

Question 30 (continued)

(a) Use the ^{13}C NMR spectrum on the previous page to identify the number of the carbon environments in the compound. **1**

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(b) Using the infrared spectrum on the previous page, complete the table below for one significant absorption in the range 4000 – 2000 cm^{-1}. **2**

Wavenumber range of absorption (cm^{-1})	*Bond responsible for absorption*
....	....

(c) Identify the name and structure of the compound. Justify your answer with reference information from **EACH** spectrum. **5**

Structure	
Name	....

(d) Organic chemists generally use a combination of information from different types of spectra to determine the structure of an unknown molecule. Assess the usefulness of this approach. **2**

End of Question 30

Question 31 (4 marks)

The following method is used to determine the mass of carbon dioxide in air:

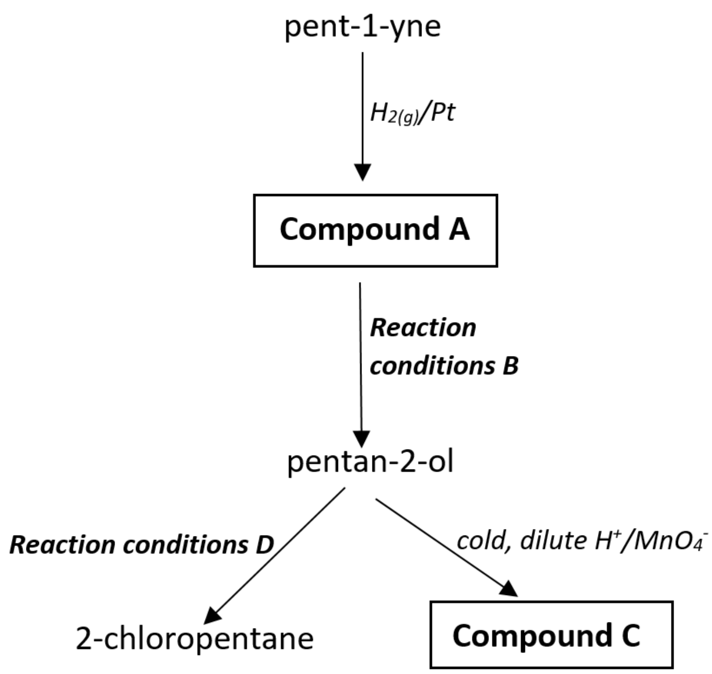
1. 50.0 L sample of air is slowly bubbled through 100.0 mL of 0.0300 M $Ba(OH)_2$ solution (carbon dioxide reacts with $Ba(OH)_2$ to form a $BaCO_3$ precipitate and water).
2. Solid $BaCO_3$ is removed via filtration.
3. Three drops of phenolphthalein is added to the filtrate turning it pink.
4. The filtrate is titrated with 0.100 M HCl.

If 25.05 mL of HCl was required for the titration, calculate the mass of carbon dioxide in the 50.0 L of the air sample. **4**

End of Question 31

Question 32 (4 marks)

The diagram below shows reactions involving five different organic compounds. **4**



Draw the structure of compounds A and C and identify the reaction conditions B and D in the boxes below:

Compound A	**Reaction conditions B** ………………………………………
Compound C	**Reaction conditions D** ………………………………………

End of Question 32

Question 33 (10 marks)

Grey Goose vodka is an alcoholic drink from France that is made from the fermentation of potatoes and cereal grains. It has an ethanol content of 40% (v/v) which is equivalent to 6.8 mol L^{-1}.

Jemima has decided to perform an experiment to find out the concentration of ethanol in Grey Goose vodka.

Below are her notes on the experiment:

Method:

For each titration a 20.00 mL aliquot of Grey Goose Vodka was transferred into a conical flask and titrated against a 5.02 M solution of potassium permanganate ($KMnO_4$). The reaction equation is given below:

$$4MnO_4^-(aq) + 5C_2H_5OH(aq) + 12H^+(aq) \rightarrow 4Mn^{2+}(aq) + 5CH_3COOH(aq) + 11H_2O(l)$$

The permanganate ion (MnO_4^-) ion was an intensely pink colour and the Mn^{2+} ion was colourless.

Results:

The titre volumes and observations made during the experiment are in the table below:

Titration number	*Titre* (mL)	*Observations*
1	23.22	Add first drop of $KMnO_4$, contents of reaction flask turn pink immediately, then after few seconds turn colourless. Add second drop of $KMnO_4$ and contents turn pink and immediately turn colourless. Keep adding $KMnO_4$ in a slow stream, contents remain a very slight pink colour. Stop stream, contents turn colourless immediately. Bubbles are observed on the surface of the solution. $KMnO_4$ is added dropwise until colour change is persistent for ten seconds.
2	23.20	As for titration 1
3	24.01	$KMnO_4$ added as a stream initially, contents of reaction flask turn pink immediately, after a few seconds content turn colourless. Brown solid observed on bottom of flask.
4	23.21	As for titration 1
5	23.22	As for titration 1

The average of the concordant titres is 23.21 mL.

Question 33 continues on the next page

Question 33 (continued)

(a) Calculate the ethanol content in Grey Goose Vodka in mol L^{-1} using the titration data provided. **3**

(b) Evaluate Jemima's experiment by addressing the following points: **7**

- evaluate the validity of the method by referring to Jemima's observations and the information below:
  - acetic acid reacts with $KMnO_{4(aq)}$ to form carbon dioxide
  - $Mn^{2+}_{(aq)}$ can act as a catalyst for the reduction of $MnO_4^-{}_{(aq)}$ ions to form $MnO_{2(s)}$
  - $MnO_{2(s)}$ is a brown solid
- evaluate the reliability of the titration results AND offer an explanation for any outliers
- evaluate the accuracy of the ethanol content calculated considering the sources of error

End of Question 33

End of Paper

Answer Key

Question	Answer
1	C
2	C
3	D
4	B
5	A
6	A
7	D
8	B
9	B
10	B
11	C
12	D
13	C
14	B
15	D
16	C
17	B
18	B
19	A
20	A

Worked solutions are provided on the next page

1 A blue-green flame appears due to the emission spectrum of copper, whereas barium and calcium produce yellow-green and orange-red flame colours, respectively. Magnesium ions in solution do not produce a flame colour (heating solid magnesium produces a bright white glare due to the exothermic production of solid magnesium oxide).

2 The structural formula shown is ethanoic acid which belongs to the homologous series of carboxylic acids, $CH_3(CH_2)_nCOOH$.

3 Adding a catalyst does not influence the yield of an equilibrium reaction; it only increases the rate of reaction in both the forward and reverse directions by reducing the activation energy barrier. Decreasing the volume has no effect on the equilibrium as there are two moles of gaseous chemicals on both sides of the reaction. Increasing the temperature favours the endothermic forward reaction to partially counteract the introduction of heat energy by Le Chatelier's principle, producing more iodine in the process. Decreasing the temperature has the opposite effect.

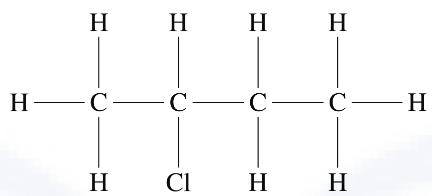
4 Equilibrium constant expressions are given by $\dfrac{\prod[\text{products}]^m}{\prod[\text{reactants}]^n}$ where m and n are the coefficients of each chemical species in the chemical equation. Therefore, $K_{eq} = \dfrac{[CdBr_4{}^{2-}]}{[Cd^{2+}][Br^-]^4}$.

5 $HSO_4{}^-$ donates a proton to N_2H_4 to produce $N_2H_5{}^+$ and $SO_4{}^{2-}$. Therefore, $HSO_4{}^-$ is a Bronsted-Lowry acid and $SO_4{}^{2-}$ is its conjugate base (one fewer hydrogen atom).

6 From Question 4, a large concentration of products corresponds to a large K_{eq} value (numerator is larger).

7 In tertiary alcohols, the carbon atom bonded to the hydroxyl group is also bonded to three other carbon atoms. This is not the case with 3,3-dimethylbutan-1-ol, 3,3-dimethylbutan-2-ol, and 2,3-dimethylbutan-1-ol, where the carbon atom bonded to the hydroxyl group is bonded to 1, 2, 1 other carbon atoms.

8 An addition reaction occurs when HCl is synthesised with but-2-ene. This involves the breakage of the carbon-carbon double bond with the H and Cl atoms bonded to each carbon atom involved in the addition reaction. As a result, the following compound is formed:



which has the systematic name 2-chlorobutane.

9 The ionisation of hypochlorous acid in water forms the equilibrium system:

$$HOCl\ (aq) + H_2O\ (l) \rightleftharpoons H_3O^+\ (aq) + OCl^-$$

This equilibrium system has the equilibrium constant expression $K_{eq} = \dfrac{[H_3O^+][OCl^-]}{[HOCl]}$ and as K_{eq} is small (weak acids ionise partially), the denominator is large, and consequently, $[HOCl] > [H_3O^+]$.

10 We know that $pH = -\log_{10}[H_3O^+]$, so rainwater has a hydrogen ion concentration 10^5 times more than soap. A higher pH corresponds to a lower $[H_3O^+]$ concentration, and thus seawater has a hydrogen ion concentration lower than stomach acid, and likewise for baking soda and lemon juice.

11 A yellow colour in thymol blue indicates $pH > 2.8$. A yellow colour in methyl red indicates $pH > 6.3$. A blue colour in bromothymol blue indicates $pH > 7.6$. No colour in phenolphthalein indicates $pH < 8.3$. Therefore, $7.6 < pH < 8.3$.

12 Sulfuric acid is a diprotic acid while acetic acid is a monoprotic acid. Both acids have the same volume and concentration, so the volume of NaOH solution required to neutralise the sulfuric acid solution is double of that of the acetic acid solution. The following method gives the full calculation although unnecessary.

The neutralisation reaction between acetic acid and sodium hydroxide is represented by the following chemical equation:

$$CH_3COOH\ (aq) + NaOH\ (aq) \longrightarrow CH_3COONa\ (aq) + H_2O\ (l)$$

Using the 1:1 mole ratio of CH_3COOH and NaOH,

$$n(CH_3COOH)_{\text{reacted}} = n(NaOH)_{\text{reacted}}$$

$$c_{CH_3COOH}v_{CH_3COOH} = c_{NaOH}v_{NaOH}$$

$$0.025 \times 0.100 = 0.0222 \times c_{NaOH}$$

$$\therefore c_{NaOH} = \frac{0.025 \times 0.100}{0.0222} = 0.113\,\text{mol L}^{-1}$$

The neutralisation reaction between H_2SO_4 and NaOH is represented by the following chemical equation:

$$H_2SO_4\ (aq) + 2\,NaOH\ (aq) \longrightarrow Na_2SO_4\ (aq) + 2\,H_2O\ (l)$$

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Using the 1:2 molar ratio of H_2SO_4 and NaOH,

$$n(\text{NaOH})_{\text{reacted}} = 2n(\text{H}_2\text{SO}_4)_{\text{reacted}}$$

$$c_{\text{NaOH}}v_{\text{NaOH}} = 2c_{\text{H}_2\text{SO}_4}v_{\text{H}_2\text{SO}_4}$$

$$0.113v_{\text{NaOH}} = 2 \times 0.025 \times 0.100$$

$$\therefore v_{\text{NaOH}} = \frac{2 \times 0.025 \times 0.100}{0.113} = 44.40\,\text{mL}$$

13 The carbon-carbon double bond is the priority functional group and hence is given the lowest locant. The carbon-carbon double bond is between the 2nd and 3rd carbon atom, and so the suffix is 2-ene. The parent chain contains 6 carbon atoms, and so the parent prefix is hex-. There are two bromine atoms bonded to the 4th carbon atom, and one chlorine atom bonded to the 6th carbon atom, which have the prefixes 4,4-dibromo and 6-chloro, respectively. B comes before C in the alphabet, so bromo- is positioned before chloro-. Thus, the IUPAC name of the molecule is 4,4-dibromo-6-chlorohex-2-ene.

14 $Q = \frac{[\text{H}_2][\text{I}_2]}{[HI]^2} = \frac{0.50 \times 0.10}{2.0^2} = 0.0125 < 0.020 = K_{eq}$. Hence, the equilibrium favours the forward reaction to increase the concentration of products to thereby increase the value of Q, approaching $Q = K_{eq}$. As a consequence, more H_2 and I_2 is produced.

15 The proton NMR spectrum shows one singlet peak indicating that the molecule contains one unique hydrogen environment, whose hydrogen atoms are adjacent to zero others due to no proton-proton coupling. The only molecule that satisfies this condition is propanone.

16 The isomer shown is 2-methylbutane, with the molecular formula C_5H_{12}. The other two isomers are dimethylpropane and pentane.

17 Let the weak acid be HA (monoprotic), with the ionisation equation:

$$\text{HA (aq)} + \text{H}_2\text{O (l)} \rightleftharpoons \text{H}_3\text{O}^+ \text{(aq)} + \text{A}^- \text{(aq)}$$

We are given that $\text{pH} = -\log_{10}[\text{H}_3\text{O}^+] = 3.6 \implies [\text{H}_3\text{O}^+] = 10^{-3.6}\,\text{mol L}^{-1}$.

Also, $[\text{H}_3\text{O}^+]$=$[\text{A}^-]$ due to the 1:1 molar ratio, and so $K_a = \frac{[\text{H}_3\text{O}^+][\text{A}^-]}{[\text{HA}]} = \frac{[\text{H}_3\text{O}^+]^2}{[HA]}$.

Using the assumption that negligible acid molecules ionised, $[\text{HA}] = 0.0200\,\text{mol L}^{-1}$.

Therefore, $K_a = \frac{(10^{-3.6})^2}{0.0200} = 3.15 \times 10^{-6}$.

18 The neutralisation reaction between HCl and NaOH is represented by the following chemical equation:

$$HCl\ (aq) + NaOH\ (aq) \longrightarrow NaCl\ (aq) + H_2O\ (l)$$

From the chemical equation, HCl and NaOH react in 1:1 ratios.

Also, $n = cv$ so $n(\text{HCl}) = 0.2 \times 0.05 = 0.01\,\text{mol}$ and $n(\text{NaOH}) = 0.1 \times 0.05 = 0.005\,\text{mol}$.

Therefore, as $n(\text{NaOH})_{\text{reacted}} = n(\text{HCl})_{\text{reacted}}$, NaOH is the limiting reagent, and $n(\text{HCl})_{\text{excess}} = n(\text{HCl})_{\text{initial}} - n(\text{NaOH})_{\text{reacted}} = 0.01 - 0.005 = 0.005\,\text{mol}$.

Also, HCl is a strong acid and thus ionises completely, so $n(\text{HCl}) = n(\text{H}^+) = 0.005\,\text{mol}$.

The resulting volume of the solution is 100 mL, and so $[\text{H}^+] = \dfrac{n}{v} = \dfrac{0.005}{0.1} = 0.05\,\text{mol L}^{-1}$.

Finally, $\text{pH} = -\log_{10}[\text{H}^+] = -\log_{10} 0.05 = 1.3$.

19 At the reestablishment of equilibrium, the concentration of A has changed twice as much as the concentration of B, so A:B is 2:1. Decreasing the temperature favours the exothermic reaction to partially counteract the loss of heat by Le Chatelier's principle, which consequently increases the concentration of B. Hence, the equation $2\,\text{A} \rightleftharpoons \text{B} \quad (\Delta H < 0)$ is correct.

20 It is given that the solubility of lead (II) iodide is $0.76\ \text{g L}^{-1}$, and so both solutions will be saturated, with solid lead (II) iodide at the bottom of the beaker. Therefore, the concentration of lead (II) iodide is 1:1.