

2019 Sample HSC Chemistry Paper #2

General Instructions

- Reading Time - 5 minutes
- Working time - 3 hours
- Please write using black pen.
- Draw diagrams using a pencil.
- NESA approved calculators are permitted.
- A Formula Sheet, Data Sheet and Periodic Table are supplied and attached at the back of this paper (booklet). **
- Please provide full working out in your responses to Section II questions.

****NOTE:** There will **NOT** be a Formula, Data Sheet and Periodic Table attached for this paper until I make one. So, use the one on NESA website when attempting this paper. However, for the official paper on HSC Day, you **WILL** be provided with a formulae sheet, data sheet and periodic table attached at the back of your exam paper (booklet).

Section I - 20 marks

Section II - 80 marks

Total Marks / 100

SECTION I

Question 1: Which of the following reactions have the largest increase in entropy?

- (A) $2A_2B(l) \rightarrow 2A_2(g) + B_2(g)$
- (B) $2A_2B(l) \rightarrow 2A_2(l) + B_2(l)$
- (C) $A_2B(g) \rightarrow A_2B(l)$
- (D) $A_2B(l) \rightarrow A_2B(s)$

Question 2: The correct relationship for the equilibrium constant is

- (A) K_f / K_r
- (B) $K_f K_r$
- (C) $K_f - K_r$
- (D) K_r / K_f

Question 3: Suppose that the equilibrium constant for the decomposition of gaseous hydrogen iodide into hydrogen gas and iodine gas is 0.0198 at 448 degrees Celsius. You found that at the same conditions, the gases have the following partial pressures at equilibrium. Determine the partial pressure of hydrogen iodide.

Gas	Partial pressure (atm)
Hydrogen Gas	0.710
Iodine Gas	0.888

- (A) 0.125
- (B) 7.87
- (C) 5.64
- (D) 0.389

Question 4: How many ^{13}C NMR signals do you expect the following molecule to have?



- (A) 3
- (B) 4
- (C) 5
- (D) 6

Question 5: Suppose that you want to determine the exact composition of chromium and iron in a metal alloy. Which of the following technology should you use?

- (A) Gravimetric Analysis
- (B) Atomic Absorption Spectroscopy
- (C) Proton NMR
- (D) Infrared Spectroscopy

Question 6: Under standard conditions, it is possible to oxidise primary alcohol to a

- (A) Carboxylic Acid
- (B) Aldehyde
- (C) Ketone
- (D) Both A and B

Question 7: It is said that ethanol burns more cleanly than octane. What is this statement referring to in chemical terms?

- (A) Ethanol will consume more oxygen than octane.
- (B) Ethanol requires less oxygen than octane to under complete combustion.
- (C) Ethanol requires more oxygen than octane to undergo complete combustion.
- (D) Ethanol can be manufactured to be a biofuel meaning that it is more environmentally friendly than octane.

Question 8: Which of the following justifies the need to remove sodium ions from the flame test instrument prior to testing other metals.

- (A) Sodium is commonly found in most environments.
- (B) Sodium produces a bright yellow glow which can obscure the colour of the metal ion being tested.
- (C) Sodium produces a bright white glow which is harmful your eye.
- (D) The platinum wire is dipped into concentrated HCl and heated on a blue flame Bunsen burner to ensure that the experiment is valid.

Question 9: Suppose that your teacher wants you to prepare a buffer with a pH of 10. Which of the weak bases below should you use?

Weak Base	K_b
X	2.1×10^{-2}
Y	6.0×10^{-4}
Z	9.0×10^{-8}
K	3.3×10^{-10}

- (A) X
- (B) Y
- (C) Z
- (D) K

Question 10: For the dissolution of sodium hydroxide in water and raising the temperature of water, which of the following is correct?

	Change in system's enthalpy	Change in system's entropy
(A)	Positive	Positive
(B)	Positive	Negative
(C)	Negative	Negative
(D)	Negative	Positive

Question 11: The forward rate of a reaction between substance Y and Z is equal to

$$\text{Rate of forward reaction} = k_{\text{forward}}[\text{Y}]^2[\text{Z}]$$

You are told that k_{forward} is the rate constant for the forward reaction. Suppose that you removed from substance Y from the reaction vessel, precisely so that only 50% of its initial concentration is left over.

In order for the forward rate of reaction to proceed at half of its initial rate, what must the concentration of substance Z be?

- (A) Same as its initial concentration
- (B) Reduced by 25% compared to its initial concentration
- (C) Reduced by 50% compared to its initial concentration
- (D) Doubled compared to its initial concentration

Question 12: Calculate the resulting concentration of Pb^{2+} when 0.1L of lead (II) chloride of 0.1M reacted with equal volume of sulfuric acid at 0.05M.

- (A) 0.050M
- (B) 0.750M
- (C) 0.030M
- (D) 0.025M

Question 13: Which of the following is AgCl least soluble in?

- (A) 0.1M of Iron (III) Chloride
- (B) 0.1M of Sodium Chloride
- (C) 0.1M of Potassium Chloride
- (D) 0.1M of Silver Nitrate

Question 14: Which of the following is true for the molar solubility of the compounds AB_2 and AZ_3 .

- (A) AB_2 has a higher molar solubility than AZ_3
- (B) AZ_3 has a higher molar solubility than AB_2
- (C) Both AB_2 and AZ_3 has equal molar solubility
- (D) More information is required to arrive to a conclusion

Question 15: Which of the following 0.5M solutions is expected to have the lowest pH?

- (A) Na_2CO_3
- (B) Na_3PO_4
- (C) Na_2S
- (D) $NaCl$

Question 16: Which of the following statements is true for mass spectroscopy (MS)?

- (A) The analyte molecule is transformed into gaseous ions
- (B) Gaseous ions are detected based on their mass-to-charge ratio
- (C) From MS data, both isotopic mass and ratios can be seen
- (D) A, B and C correct

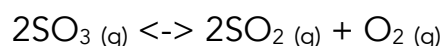
Question 17: Which of the following is the explains the primary reason for the use of infrared spectroscopy (IR) in analysing the structure of organic compounds?

- (A) Elements absorb a specific wavelength of energy.
- (B) All chemical bonds absorb infrared radiation
- (C) The intensity of the peaks displayed on the IR spectra helps determine the molecule mass of the organic compound
- (D) The majority of organic compounds' functional groups are able to absorb infrared radiation.

Question 18: Which of the following best describes the shape of the central carbon atoms in ethylene?

- (A) Bent
- (B) Tetrahedral
- (C) Trigonal Planar
- (D) Linear

Question 19: The K_p for the following equilibrium reaction:



At one thousand degrees Celsius is approximately 0.3. However, when the temperature is increased by 300 degrees Celsius, the K_p is 41. Which of the following is true?

	Change in system's enthalpy	Change in system's entropy
(A)	Zero	Zero
(B)	Greater than Zero	Greater than Zero
(C)	Greater than Zero	Less than Zero
(D)	Less than Zero	Less Than Zero

Question 20: A flame test for a solution of potassium nitrate would produce a flame of what colour?

- (A) Apple-green
- (B) Violet
- (C) Brick-Red
- (D) Yellow

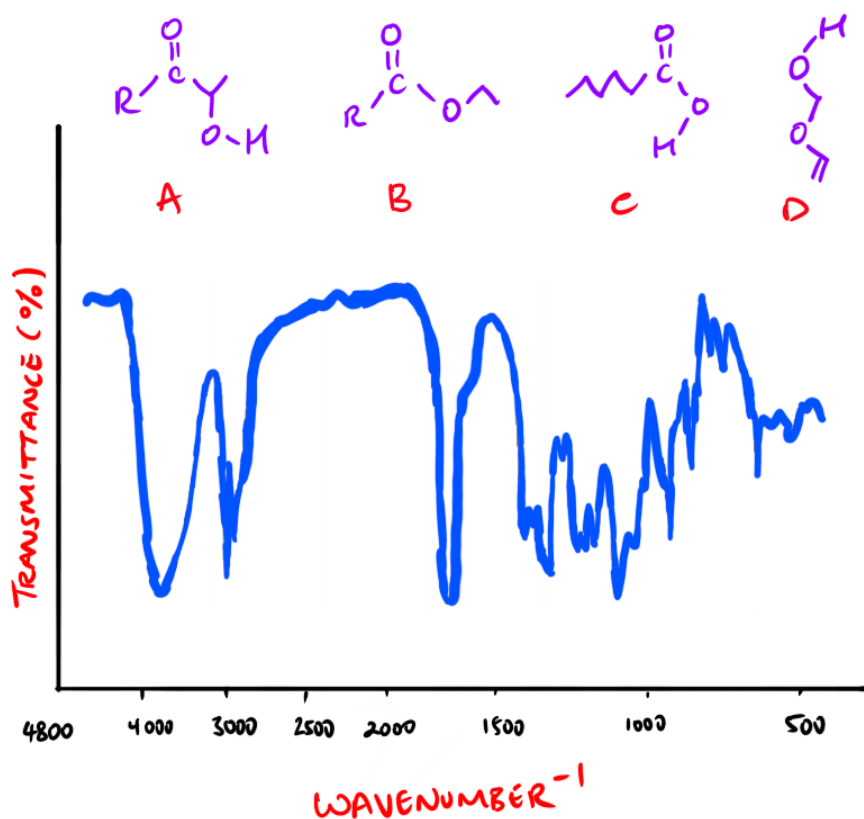
SECTION II

Question 21:

(a) Given that hypochlorous acid (HOCl) is a weak acid, write the chemical equation for the reaction between HOCl and H_2O . [3 marks]

(b) Explain the reason to why NaOCl is basic. Use a relevant chemical equation to support your answer. [3 marks]

Question 22: Explain which molecule (A, B, C or D) does the following infrared radiation (IR) spectrum diagram belong to. [8 marks]



WAVENUMBER⁻¹

Question 23: Draw a ^1H NMR spectrum for ethanol with chemical shift between 0 to 4 ppm. Show signals for CH_2 , OH and CH_3 & the number of peaks in each signal. [6 marks]

Question 24: Suppose you have 100mL of 0.5 mole of H_2SO_4 and 200mL of 1 mole of KOH. You have both them reacting in a calorimeter.

Suppose that you are told that the enthalpy due to neutralisation for the reaction between sulfuric acid and potassium hydroxide is -57kJ per one mole of water formed.

The heat capacity of the calorimeter is 30 J/K.

The initial temperature of H_2SO_4 is 23.5°C and the temperature at which KOH is added is 25.6°C .

Calculate the temperature of the solution after neutralisation. [6 marks]

Question 25: Discuss the how the properties of soaps and detergents account for their uses in our everyday lives. Include a relevant diagram in your answer. **[6 marks]**

Question 26: Compare the uses of nylon and polyesters by relating it to their structure and properties. **[6 marks]**

Question 27: Suppose you have two beakers. You have been informed that one beaker contains potassium acetate and the other contains potassium chloride. Describe a suitable procedure that you could carry out to confirm the chemical identity of the substance stored in each beaker. Use a flowchart to illustrate your procedure. **[5 marks]**

[illegible]

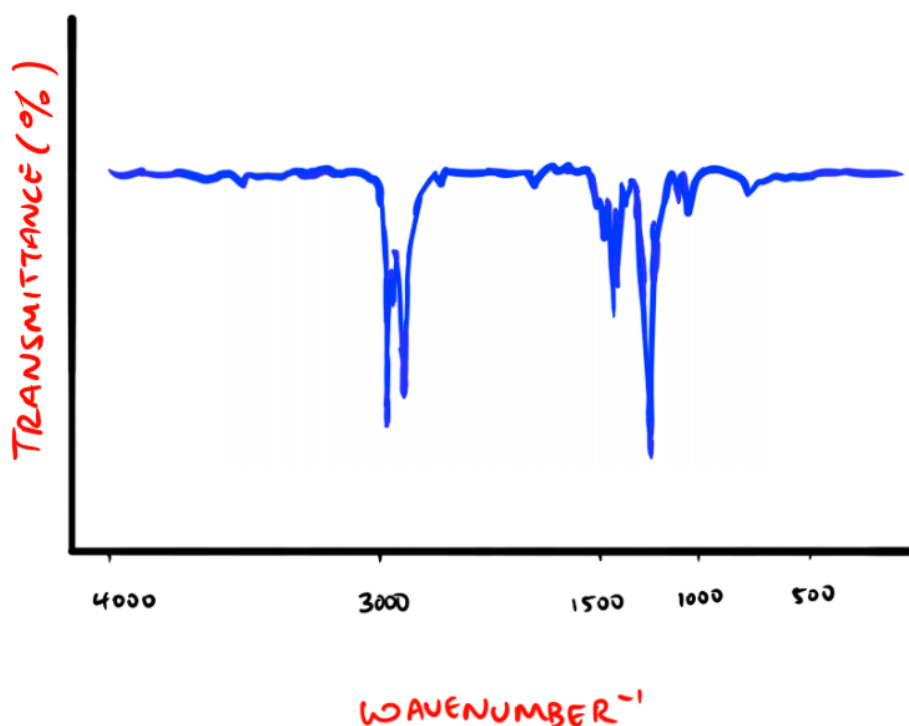
Question 28: Explain three conditions that must be satisfied in order to successfully perform a precipitation titration in which useful results can be obtained. **[6 marks]**

Question 29: Account for the need to monitor water quality. [5 marks]

Question 30: Five grams of an unknown organic compound had undergone complete combustion to produce 12 grams of carbon dioxide and 6 grams of water.

(a) Write the empirical formula for the unknown organic compound. [3 marks]

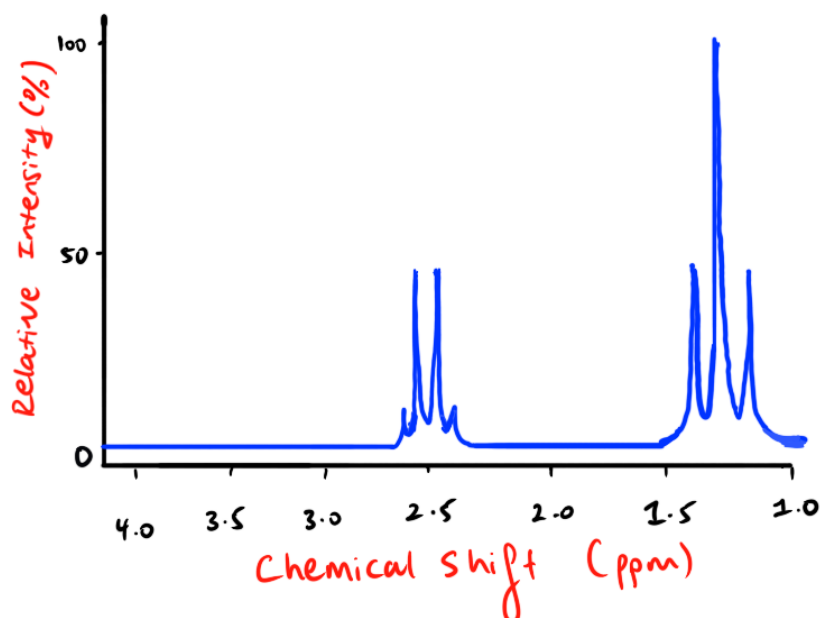
(b) Interpret the following IR spectrum diagram.



Which bond in the compound gives the signal shown at 1140 cm⁻¹? [1 mark]

(c) The molecular ion of the organic compound has a mass-to-charge ratio of 74, write the molecular formula for the organic compound. [2 marks]

(d) You are given the following NMR spectra for the same organic compound. Draw the structural formula for the organic compound. [2 marks]



Question 31: Three molecules and their maximum wavenumber of infrared radiation absorption are displayed below. Account for their difference in IR absorption. [4 marks]

Molecule	Absorption due to bond between carbon and hydrogen.
Hex-1-yne	3300
Hex-1-ene	3100
Hexane	2900

Question 32: You are given the data that 0.002 grams of $\text{Ca}_3(\text{PO}_4)_2$ will dissolve in 100 grams of water at 25 degrees Celsius.

(a) Express the solubility product constant expression for $\text{Ca}_3(\text{PO}_4)_2$ [1 mark]

(b) Calculate the solubility of $\text{Ca}_3(\text{PO}_4)_2$ in mol/L at the same temperature. [2 marks]

(c) Compute the K_{sp} for calcium phosphate at 25 degrees Celsius. [2 marks]

(e) Suppose that you added the same amount of calcium phosphate into a 0.200M NaF solution, rather than 100 grams of water.

Explain how the solubility of $\text{Ca}_3(\text{PO}_4)_2$ would change and include at least one chemical equation in your answer. No calculations required. [3 marks]

Question 33: Using the data in the following table, account for the differences in electrical conductivity and pH between hydrochloric acid & propanoic acid. [4 marks]

Property	Hydrochloric Acid	Propanoic Acid
Concentration of acid solution	0.100M	0.100M
Relative electrical conductivity of acid solution	High	Low
pH of acid solution	1.00	1.00

Question 34: Name and justify your choice of an indicator that is suitable for use in a titration between NaOH and CH₃COOH. [3 marks]

END OF EXAM

Check FULL sample solutions & marking guidelines -
www.conquerhsc.com

Warmest,
ConquerHSC Team

Sample HSC Chemistry Paper 1

Marking Guidelines & Sample Solutions

NOTE: The following sample solutions are examples of a **Band 6 response**. Depending on the marking criteria as shown below, there **MAY NOT** be a **definitive** answer to a specific question. That is, there could be **multiple answers** that satisfies the same marking criteria or question.

Section I Solutions

- Q1) C
- Q2) B
- Q3) B
- Q4) A
- Q5) C
- Q6) A
- Q7) C
- Q8) B
- Q9) B
- Q10) B
- Q11) A
- Q12) B
- Q13) A
- Q14) A
- Q15) C
- Q16) C
- Q17) D
- Q18) B
- Q19) A
- Q20) C

NOTE: Feel free to DM me on Discord or post in ConquerHSC's Discord Community for full working out for MC Questions, a HSC Chemistry Mentor will answer ASAP. 😊

Section II Solutions

Q21 – Sample Answer

A static equilibrium is a state of a system at equilibrium whereby both reactants and products are no longer being between each other. Comparatively, dynamic equilibrium also refers to a system at equilibrium, but, the reactants are being converted into products and vice versa.

Since both states are at equilibria, the change in the species' concentration involved in the reaction is constant, i.e. zero, for both static and dynamic equilibrium. This is because the forward and reverse rate of reaction is equal for both static and dynamic equilibrium.

For static equilibrium, the forward and reverse rates of reaction are both zero. Vice versa, for dynamic equilibrium, the forward and reverse rates of reaction are greater than zero. Systems found at static equilibrium could be opened or closed whereas dynamic equilibrium are only found in closed systems (under normal conditions).

Another possible difference: Static equilibria are irreversible whereas dynamic equilibria are reversible.

Another possible similarity: Systems at static and dynamic equilibrium are steady-state systems as external factors that affect the equilibrium position are cancelled out (or balanced) such that a state of equilibrium can be reached.

Q21 - Marking Criteria:

1 mark = Definition of static and dynamic equilibrium.

2 mark = Two differences between static and dynamic equilibrium.

2 mark = Two similarities between static and dynamic equilibrium.

ConquerHSC Notes Reference: ⇒ [Week 1 Notes – Module 5](#)

Q22 – Sample Answer

Lavoisier proposed the oxygen theory of acids where non-metal compounds that contains one or more oxygen atom(s) will act as acids when dissolved in water. This theory is based off the theory that oxygen atom gave non-metal oxides their acidic properties.

Davy expanded Lavoisier's oxygen theory of acid by stating that substances that contained hydrogen atoms allowed the acid to have their acidic properties. This was known as Davy's hydrogen theory of acids.

Justus von Liebig then refined Davy's hydrogen theory of acids where the acidic substance must contain a hydrogen that is replaceable by another substance (e.g. a metal).

Arrhenius furthered Davy's hydrogen theory of acids by stating that acid are substances that dissociate and produce hydrogen ions (rather than neutral hydrogen atom) in solution when dissolved in water. Bases are substances that dissociate and produce hydroxide ions in solution when dissolved in water. The higher the degree of dissociation of the acid or base, the stronger they are. He also stated that neutralization reaction are a result of hydrogen ions and hydroxide ions reacting with each other to form water.

Proton Theory of Acids and Bases was proposed by Bronsted & Lowry where acids are substances that are capable of donating a proton (hydrogen ion). Vice versa, bases are substances that are capable of accepting a proton. This helps account for acid-base reactions that are not strictly in aqueous solutions requiring both the dissociation of hydrogen ions and hydroxide ions in water.

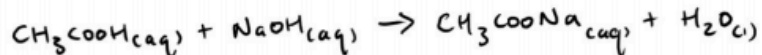
Q22 - Marking Criteria:

4 marks - Description of theories of acids and/or bases proposed by Lavoisier, Davy (or Justus von Liebig), Arrhenius and Bronsted-Lowry.

1 mark - Clearly explains how theories are built on each other with an example.

[ConquerHSC Notes Reference](#) ⇒ [Week 5 Notes – Module 6](#)

Q23 – Sample Answer



I	0.01 mol	0.006 mol	0	—
C	-0.006 mol	-0.006 mol	+0.006 mol	—
E	0.004 mol	0	0.006 mol	—

NOTE: NaOH is limiting reagent.

$$\text{Total Volume} = 60 \text{ mL} + 100 \text{ mL} = 160 \text{ mL} = 0.16 \text{ L}$$

$$[\text{CH}_3\text{COOH}]_{\text{eq}} = \frac{0.004 \text{ mol}}{0.16 \text{ L}} = 0.025 \text{ M}$$

$$[\text{CH}_3\text{COONa}]_{\text{eq}} = \frac{0.006 \text{ mol}}{0.16 \text{ L}} = 0.0375 \text{ M}$$

$$K_a \text{ for acetic acid} = \frac{[\text{H}^+][\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]}$$

$$1.8 \times 10^{-5} = \frac{[\text{H}^+][\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]}$$

We want $\text{pH} = -\log_{10}[\text{H}^+]$; hence, we isolate $[\text{H}^+]$

$$[\text{H}^+] = \frac{(1.8 \times 10^{-5}) \times [\text{CH}_3\text{COOH}]_{\text{eq}}}{[\text{CH}_3\text{COO}^-]_{\text{eq}}}$$

; we calculated $[\text{CH}_3\text{COOH}]_{\text{eq}}$ and $[\text{CH}_3\text{COO}^-]_{\text{eq}}$.

$$\therefore [\text{H}^+] = \frac{(1.8 \times 10^{-5}) \times (0.025)}{(0.0375)} = 1.2 \times 10^{-5}$$

$$\text{pH}_{\text{solution}} = -\log_{10}[\text{H}^+] = -\log_{10}(1.2 \times 10^{-5}) = 4.9$$

**Final Answer to correct significant figures = 5 (1 s.f)

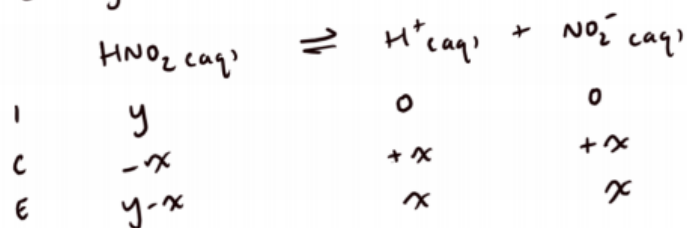
Q23 - Marking Criteria:

- 1 mark - correct chemical equation
- 1 mark - identifies NaOH is the limiting reagent
- 1 mark - correct K_a expression
- 1 mark - correct $[\text{H}^+]$
- 1 mark - correct pH to correct decimal places.

ConquerHSC Notes Reference \Rightarrow [Week 3 & 7 Notes – Module 5 & 6](#)

Q24 – Sample Answer

Let "y" be the initial concentration of HNO_2 .



$$K_a \text{ of } \text{HNO}_2 = 6.0 \times 10^{-4} = \frac{[\text{H}^+][\text{NO}_2^-]}{[\text{HNO}_2]}$$

$$\therefore 6.0 \times 10^{-4} = \frac{x^2}{y-x}$$

Given that $\text{pH} = 3.65$, $[\text{H}^+] = 10^{-\text{pH}} = 10^{-3.65}$
 $\therefore [\text{H}^+] = 2.23 \times 10^{-4}$

Since $[\text{H}^+]_{\text{eq}} = x$,

$$6.0 \times 10^{-4} = \frac{(2.23 \times 10^{-4})^2}{y - 2.33 \times 10^{-4}}$$

$$\therefore y - 2.33 \times 10^{-4} = \frac{(2.33 \times 10^{-4})^2}{6.0 \times 10^{-4}}$$

$$y = \frac{(2.33 \times 10^{-4})^2}{6.0 \times 10^{-4}} + (2.33 \times 10^{-4})$$

$$\therefore \text{Initial } [\text{HNO}_2] = 3 \times 10^{-4} \text{ M.}$$

(aka "y")

**Final answer to correct significant figures = 3.0×10^{-4} (2 s.f)

Q24 - Marking Criteria:

- 1 mark = correct chemical equation
- 1 mark = correct K_a expression
- 1 mark = correct $[\text{H}^+]$
- 1 mark = correct initial HNO_2 concentration

ConquerHSC Notes Reference \Rightarrow Week 3 & 7 Notes – Module 5 & 6

Q25 – Sample Answer

In order for silver chloride to dissolve in water, the hydrogen bonding between water molecules (the solvent) must be broken.** Similarly, the ionic bonds between silver and chlorine ions must also be broken.

As bond-breaking processes require energy, the energy released by the formation of the ion-dipole force/bond must be greater than the total energy required to break the ionic bonds and intermolecular force between water molecules. If not, the dissolution of $\text{AgCl}_{(s)}$ molecule(s) will occur.

The formation of the ion-dipole is due to the partially negatively charged oxygen atoms in water molecules being attracted to the silver cation. Likewise, the partially negatively charged hydrogen atoms in water molecules are attracted to the negatively charged hydrogen atoms. This attraction between water molecules and ions is an example of an ion-dipole force/bond.

At equilibrium, the rate of precipitation and dissolution are equal. Therefore, as silver and chloride ions precipitate out of solution to form $\text{AgCl}_{(s)}$, the same density of silver chloride precipitate is dissolved to form silver and chloride ions.

**** NOTE:** Yes, other intermolecular forces (or bonds) such as dipole-dipole and dispersion forces are also broken between water molecules. However, the hydrogen bonding is the major intermolecular force and its strength much greater than dipole-dipole and dispersion forces amongst water molecules.

Q25 - Marking Criteria:

1 mark = Account for changes in interaction between solvent molecules

1 mark = Account for changes in the interaction between solute molecules

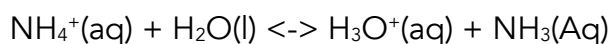
1 mark = Account for the interaction between solvent-solute molecules via ion-dipole bonds

1 mark = Explains that hydration energy must be greater than the total energy of breaking the interaction between solvent molecules (intermolecular forces such as hydrogen bonding being the main force) and ionic bond between silver and chloride ions.

1 mark = Description of what occurs at equilibrium specific to the question where the rate of precipitating silver chloride solid is equal to the rate at which silver chloride dissociate into silver and chloride ions in water. A general answer of forward rate of reaction is equal to the reverse rate of reaction could be accepted.

[ConquerHSC Notes Reference](#) ⇒ [Week 4 Notes – Module 5](#)

Q26 – Sample Answer



Upon dissolution, ammonium ion will react with water as a Bronsted-Lowry acid. On the side of the token, water will act as a Bronsted-Lowry base. As a result, hydronium ion and ammonia are formed products. Since hydronium ion is a strong acid and ammonia is a weak base, the resulting ammonium chloride solution is acidic.

Chloride ion does not affect the resulting pH at an appreciable level as it is a very weak conjugate base of the strong acid, HCl. Therefore, the amount of chloride ion that accept a proton by react with water and form hydroxide ions is insignificant compared to the effect of ammonium ions in forming hydronium ions. Therefore, the resulting pH of the ammonium chloride solution is acidic.

Q26 - Marking Criteria:

1 mark = Correct, appropriate, relevant chemical equation.

1 mark = Explaining that ammonium ion acts as an acid whereas water acts as a base.

1 mark = Hydronium ion is a strong acid whereas ammonia is a weak base, resulting in overall solution to be acidic.

1 mark = Chloride ion does not interact with water as it is conjugate base of strong acid HCl and therefore does not affect the pH of the resulting salt solution.

[ConquerHSC Notes Reference](#) ⇒ [Week 7 Notes – Module 6](#)

Q27 – Sample Answer

In the wine industry, it is important to analyse the volatile, organic acid (e.g. acetic acid) content in wine as their concentration is proportional to the susceptibility of the wine being spoiled.

Steam distillation involves adding wine sample to boiling water in a flask that is being heat to evaporate volatile acids which are then collected as distillate using a condenser. Fixed acids in wine (e.g. malic acid) are not evaporated as they have higher boiling point than water.

Titration is a process that can be subsequently performed after steam distillation. This involves titrating the wine sample against a strong base to determine the unknown concentration of the weak acid present in the wine. This is possible as a standardized strong base of known concentration is added into the weak acid of wine sample until all of the weak acid is neutralized.

Other possible techniques: Hydrometry, Paper chromatography, Liquid gas chromatography, thin layer chromatography, etc.

Q27 – Marking Criteria:

2 marks = identification of two analytical technique used in named industry/industries.

2 marks = explanation of the use of each analytical technique in named industry

ConquerHSC Notes Reference: ⇒ [Week 7 Notes – Module 7](#)

Q28 – Sample Answer

Chain, position and functional group isomers are types of structural isomers that have the same molecular formula.

Chain isomers differ in their connectivity of carbon atoms to the parent carbon chain, resulting in different parent carbon chain lengths. All structural isomers have the same parent carbon chain length.

Position isomers have one or more substituent group being different in their connectivity to the parent carbon chain. All position isomers have the same parent carbon chain length.

Functional group isomers may or may not have the same parent carbon chain length, depending on arrangement of atoms. Depending on the arrangement of atoms, it results in isomers having different functional groups.

Q28 - Marking Criteria:

1 mark = Definition of position isomers that differentiates it against chain & functional group isomers

1 mark = Definition of chain isomers that differentiates it against position & functional group isomers

1 mark = Definition of functional group isomers that differentiates it against position and chain isomers.

ConquerHSC Notes Reference: ⇒ [Week 8 Notes – Module 7](#)

Q29 – Sample Answer

Alkenes and Alkynes are unsaturated hydrocarbons that are able to undergo addition reactions. Vice versa, alkanes are saturated hydrocarbons that are not able to undergo addition reactions.

As the energy required to break a carbon-carbon bond in a saturated hydrocarbon's double carbon requires less than the energy needed to break a carbon-carbon bond in a saturated hydrocarbon, alkenes and alkynes are more reactive than alkanes. For the same reason, alkynes are more reactive than alkenes due to lower energy required to break a carbon-carbon bond.

For example, alkanes require high temperature or the presence of U.V light to react with bromine water. Comparatively, alkenes and alkynes can react with bromine water under room temperature conditions in the absence of U.V light.

Besides difference in chemical reactivity, alkynes more acidic than alkenes and alkanes are the least acidic. This reason to this is due to orbital hybridisation.

This is because alkynes are able to donate a proton more readily than alkenes followed by alkanes. The reason towards this is because lone electron pair on the carbon is sp , sp^2 and sp^3 hybridized for alkynes, alkenes and alkanes respectively. For such reason, the conjugate base of alkynes after proton donation is most stable as sp has the greatest 's' orbital character meaning that electrons are closest to the nucleus and therefore more stable due to lone pair of electrons experiencing the higher effective nuclear charged compared to sp^2 and sp^3 hybridisation of electrons in alkenes and alkanes respectively. For this is stable, alkynes are able to donate hydrogen ion more readily and therefore more acidic.

Another difference could include: Alkanes undergo complete combustion more readily than alkanes which is more easily oxidized than alkynes. This is due to the ratio between carbon to hydrogen is highest in alkynes so more oxygen is required to fully oxidise the carbon atoms, making alkynes harder to undergo complete combustion compared to alkanes and alkenes.

Q29 - Marking Criteria:

1 mark = Identifies chemical property differences (1 mark each)

2 marks = Explanation of chemical property difference (2 marks each)

[ConquerHSC Notes Reference](#) ⇒ [Week 9 Notes – Module 7](#)

Q30 – Sample Answer

(i)

Step 1: Measure 50mL of water using a 100mL measuring cylinder and transfer water into a calorimeter, recording the initial temperature of water.

Step 2: Weigh the initial mass of the spirit burner containing ethanol.

Step 3: Clamp the calorimeter on a retort stand and light the wick of the spirit burner placed closely beneath the calorimeter.

Step 4: Slowly stir the water using the thermometer as the alcohol combusts.

Step 5: Put the cap of the spirit burner when thermometer reads approximately 35 degrees Celsius.

Step 7: Weigh the final mass of the spirit to determine alcohol used.

Step 8: Repeat step 1-7 using with different alcohols with the same calorimeter and 50mL of water.

Step 9: Calculate the molar enthalpy of combustion by dividing enthalpy combustion ($\Delta H = -mc\Delta T$) by the moles of alcohol used calculated using $n = m/MM$.

(ii)

Safety Risk	Safety Precaution taken
The spirit burner is made out of glass and glass can cause cuts if accidentally dropped.	Avoid placing the spirit burner near the edge of the table before, during and after experiment.
A Bunsen burner in operation can cause serious burns.	Never reach over the flame of the Bunsen burner.

(iii) The thermometer that has wide increments can affect the accuracy of the results. A thermometer with more increments can be used to obtain a more precise temperature reading to improve the accuracy of results.

Q30 - Marking Criteria:

(i)

1 mark = Appropriate procedure used involved heating weighed water

1 mark = Measuring initial and final mass of burner, initial and final temperature

1 mark = Appropriate calculation to compute molar enthalpy of combustion by dividing ΔH .

1 mark = Identifies the use of moles of alcohol ($n = m/MM$) to calculate molar enthalpy

(ii)

2 marks = two risk identified and appropriate safety precaution taken for each risk (1 mark each)

(iii)

2 marks = Correctly identifies a factor that affects the accuracy of experiment and an appropriate strategy to minimise the error.

[ConquerHSC Notes Reference](#) \Rightarrow [Week 11 Notes – Module 7](#)

Q31 – Sample Answer

In order of increasing acidity: tertiary alcohol, secondary alcohol, primary alcohol. The reason behind this is that there are more alkyl groups in tertiary alcohol.

As the number of electron donating alkyl groups increases, the more unstable the conjugate base will be due to increased number of electrons which the conjugate base carries after the alcohol donates its hydrogen atom. Therefore, tertiary alcohols form the least stable conjugate base, thus, making it the weakest acid of the three.

Since hydrogen atom is a weaker electron donating group (fewer electrons) than alkyl groups, secondary and primary alcohols are more acidic than tertiary alcohols.

Alternative explanation: As the number of alkyl groups increase, more electron density is pushed towards the central carbon atom which passes on some of the electron density towards the oxygen atom in the hydroxyl group. As a result, the electrons that oxygen attracts from the hydrogen atom in the OH group is less extensive. Therefore, the energy required to break the OH bond increases. This makes it harder to break the O-H bond to release a H^+ ion making tertiary alcohol the least acidic category.

A second chemical property between the three alcohol categories is their differences in undergoing oxidation reactions.

Due to their different number of alkyl groups, primary alcohol can be oxidized into aldehyde and carboxylic acid but not to ketone. In the case of secondary alcohols, they can be oxidized to ketones but not to aldehyde or carboxylic acid.

Comparatively, tertiary alcohol does not readily oxidise in normal conditions unless in extreme oxidative conditions such as combustion which breaks C-C bonds.

Q31 – Sample Marking Criteria:

1 mark = Account for differences in chemical properties (e.g. acidity)

2 marks = Explanation of such differences

1 mark = Account for difference in chemical properties (e.g. oxidation capacity in normal conditions and not extreme)

2 marks = Explanation for such difference in oxidation due to different number of alkyl groups (if oxidation capacity is used as a difference)

[ConquerHSC Notes Reference](#) ⇒ [Week 11 Notes – Module 7](#)

Q32 – Sample Answer

The presence of chlorine atoms attached to carbon atoms in poly(vinyl chloride) or PVC stiffens the polymer chains. This makes pure PVC less flexible than polytetrafluoroethylene (PTFE) as chlorine atom is larger than fluorine atom. That being said, a plasticizer additive can be incorporated in the PVC's structure between polymer carbon chains during the manufacturing process to increase the distance between polymer chains, making PVC flexible. Additionally, an ultraviolet inhibitor such as TiO_2 can also be incorporated in the manufacturing process to absorb the UV radiation, preventing the low energy C-Cl bond from being broken down by sun's UV radiation.

Although the C-Cl bonds in PVC are polar, the polymer's linear structure and overall high number of non-polar C-C and C-H bonds considerably weaken the strength of the dipole-dipole bond that PVC can form with water. Due to this chemical structure, PVC is insoluble in water. The PVC polymer after adding UV absorber and plasticizer additive can be used to make gardening hoses. This is because the polymer is flexible and will not decomposed when exposed to ultraviolet radiation sunlight.

Comparatively, for PTFE, with minimal chain branching, the polymer chains are able to pack very closely together to form strong intermolecular (dispersion and dipole-dipole) forces. Due to this, the polymer has a high melting and boiling point. The high bond energy in the polymer's strong C-F bonds can be attributed to fluorine's high electronegativity. This means that most of the electrons will spend more time around the fluorine atom making it difficult to polarize the C-F bond and requiring high energy to substitute the fluorine atom from the polymer. This allows PTFE to be chemically unreactive and resistant to chemical attacks. C-F bond does not form hydrogen bond with water molecules, making PTFE is water-repellent or insoluble in water similar to PVC.

PTFE is used in the manufacture of pipelines to transfer hot chemicals as it is chemically unreactive, insoluble in water and have high melting and boiling point. These properties reduce the frequency in which pipelines will have to be replaced which effectively minimizes the downtime in business operations.

Q32 - Marking Criteria:

3 marks = Identifies a use of PTFE and relating to its structure and properties

3 marks = Identifies a use of PVC and relating to its structure and properties

[ConquerHSC Notes Reference](#) ⇒ [Week 13 Notes – Module 7](#)

Q33 – Sample Answer

These unwanted drilled rocks that are sucked up are returned into the ocean which often are contaminated with barium ions from the traces of lubricant used to increase the efficiency of the drill machine. These barium ions are toxic as they interfere with enzyme activities which can result in death of living organisms. Henceforth, there will be reduction in biodiversity of aquatic organisms. It is important to preserve biodiversity for many countries as aquatic organisms serves a major source of economic revenue.

For example, aquatic organisms sold from Philippines accounts for over \$550 billion USD dollars annually. The reduction of Philippines' aquatic organisms would result in a major hit to the country's economy and have many social implications such as poverty as fisherman's yield will decrease.

However, the oil industry operates by obtaining and selling hydrocarbon after it has undergone fractional distillation to produce products such as octane. Octane are used in cars' petrol. By obtaining hydrocarbons, countries with rich-oil reserves are able to export the oil to make profits and bring employment, both are which important in building a strong economy.

Therefore, it is important to consider and minimise the environmental consequences caused in the process of obtaining hydrocarbons in order to maximise economical profits for the country, every entity within and associated entities.

Q33 - Marking Criteria

4 mark = Explains two positive OR negative implication of obtaining hydrocarbon from Earth **OR**

4 mark = Explains one positive and one negative implication of obtaining hydrocarbon from Earth

(1 mark for identifying each implication and 1 mark for explanation of each implication)

1 mark = Overall evaluation statement of weighing the implications identified.

[ConquerHSC Notes Reference](#) ⇒ [Week 9 Notes – Module 7](#)

Q34 – Sample Answer

Colourimeter is used to examine how a specific wavelength or frequency of visible light within the visible electromagnetic spectrum is absorbed by a molecule of concern in the test sample. By comparing the absorbance value of the test sample against standardized solutions with known concentration & absorbance value of the molecule of concern on a calibration curve, the unknown concentration of the molecule of concern can be determined.

The lower the intensity the light detected, the higher the absorbance value and the higher the concentration of the molecule or atom that is present in the test sample.

While colourimeter uses an interchangeable colour filter to isolate wavelengths of light that the unknown molecule most readily absorbs to improve the accuracy of the total/true maximum absorbance value detected by a detector which is fed to an output reader.

Compared to a colourimeter, a UV-Vis spectrophotometer uses a diffraction grating or glass or quartz prism rather than a colour filter to split visible light AND ultraviolet radiation into different wavelengths. Similar to the colourimeter, the results gathered from the UV-Vis spectrophotometer of standardized solutions are plotted on a calibration curve which then can be used to determine the concentration of the molecule or atom of concern. A detector is also present in a UV-Vis spectrophotometer to detect the intensity of light exiting the sample cell and absorbance reading is shown on a readout device display.

Q34 - Marking Criteria

2 marks = Correct components of UV-Vis spectrophotometer

1 mark = Describes Difference between colourimeter and UV-Vis spectrophotometer in components

1 mark = Identifies the use of calibration curve to determine concentration as a similarity

ConquerHSC Notes Reference ⇒ [Week 14 Notes – Module 8](#)

Q35 - Sample Answer

The sample solution that reacted with propanoic acid and producing a pineapple smell will be ethanol. This is because esterification produces esters with fruity flavours by reacting an alcohol (e.g. ethanol) with an alkanoic acid such as propanoic acid. However, there will not be a reaction between two alkanoic acids, provided that they are not concentrated enough.

Vice versa, we can use the process of esterification to determine which beaker contains the ethanoic acid by adding ethanol. The beaker that reacted with ethanol to produce an ester with a fruity flavor will be ethanoic acid.

To differentiate between the remaining cyclohexene and cyclohexane solutions, the bromine water test can be used. The test involves adding five drops of bromine water into test sample of each solution in the absence of U.V light at room temperature. The solution containing cyclohexene will decolourise the bromine water as the saturated hydrocarbon reacts with the bromine water resulting in the bromine water being decolourised from orange-brown to colourless.

Vice versa, cyclohexane will not decolourise the bromine water solution as it is saturated hydrocarbons are not able to undergo addition reactions. So, the solution will remain orange-brown. As a confirmatory test, the cyclohexane-bromine water solution will be decolourised by subjecting it under the presence of U.V light or high temperatures. This is because the high energy U.V radiation or temperature is capable of causing cyclohexane to undergo substitution reaction.

Q35 - Marking Criteria

1 mark = Procedure used to identify cyclohexene and cyclohexane

1 mark = Explains how cyclohexene will react under presence of U.V light or high temp

1 mark = Procedure used to identify ethanol

1 mark = Procedure used to identify ethanoic acid

[ConquerHSC Notes Reference](#) ⇒ [Week 5 & 7 Notes – Module 6](#)

Q36 – Sample Answer

(i)

Oxidation: $\text{Fe}^{2+}(\text{aq}) \rightarrow \text{Fe}^{3+}(\text{aq})$

Reduction: $\text{MnO}_4^- (\text{aq}) + 8\text{H}^+ (\text{aq}) + 5\text{e}^- \rightarrow \text{Mn}^{2+} (\text{aq}) + 4\text{H}_2\text{O} (\text{l})$

(ii) $5\text{Fe}^{2+} (\text{aq}) + \text{MnO}_4^- (\text{aq}) + 8\text{H}^+ (\text{aq}) \rightarrow 5\text{Fe}^{3+} (\text{aq}) + \text{Mn}^{2+} (\text{aq}) + 4\text{H}_2\text{O} (\text{l})$

Using $n(\text{Fe}^{2+}) = [\text{Fe}^{2+}] \times V(\text{Fe}^{2+}) = 0.121\text{M} \times 0.020\text{L} = 0.0024 \text{ mol}$

Since the mole ratio between $\text{Fe}^{2+} : \text{MnO}_4^-$ is 5:1, it would mean that for every one mole of Fe^{2+} that is consumed, one-fifth of one mole of MnO_4^- is consumed.

Therefore, the mole of MnO_4^- reacted is $n(\text{Fe}^{2+}) / 5 = 0.0024 / 5 = 0.00048 \text{ mol}$

Note that 0.00048 mol of MnO_4^- is present in 0.0235L of KMnO_4 solution. In order to find concentration of KMnO_4 , we need to determine how many moles of MnO_4^- is present in 1L of KMnO_4 solution.

The concentration of MnO_4^- ions can be found using $c = n/V$.

$[\text{MnO}_4^-] = 0.00048 / 0.0235\text{L} = 0.020\text{M}$ (2 s.f) **OR**

$[\text{MnO}_4^-] = 0.00048 / (23.5\text{ml}/1000\text{L}) = 0.020\text{M}$ (2 s.f)

Q36 - Marking Criteria

(a)

1 mark = Correct oxidation half equation

1 mark = Correct reduction half equation

(b)

1 mark = Correct overall reaction

1 mark = Correct $n(\text{Fe}^{2+})$

1 mark = Correct moles of $n(\text{MnO}_4^-)$

1 mark = Correct concentration value to correct significant figures

ConquerHSC Notes Reference \Rightarrow Week 5 & 7 Notes – Module 6