

2019 Sample HSC Chemistry Paper #1

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

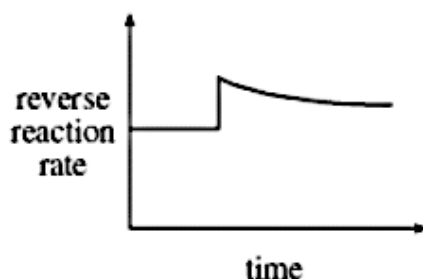
SECTION I

Question 1: Which of the following is true if the forward reaction of an equilibrium reaction is exothermic proceeding to dynamic equilibrium?

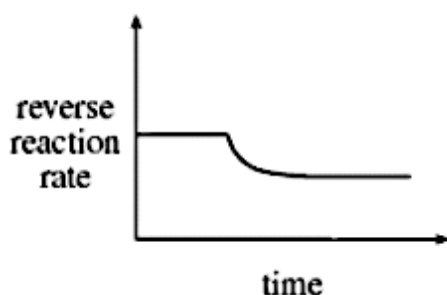
- (A) Maximum enthalpy will favour the forward reaction and maximum entropy favours the reactants.
- (B) Maximum enthalpy will favour the products and minimum entropy favours the products.
- (C) Minimum enthalpy will favour the forward reaction and the maximum entropy favours the reactants.
- (D) Minimum enthalpy will favour the products and minimum entropy will favour the reactants.

Question 2: Which of the following diagram shows the change in the rate of the reverse reaction over time if the temperature of the system is gradually reduced and eventually held constant for an exothermic reaction?

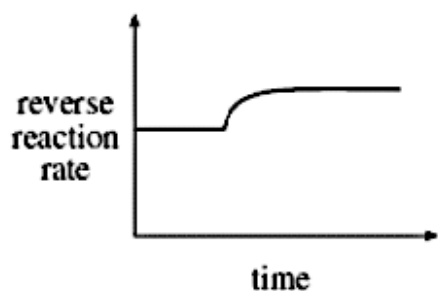
(A)



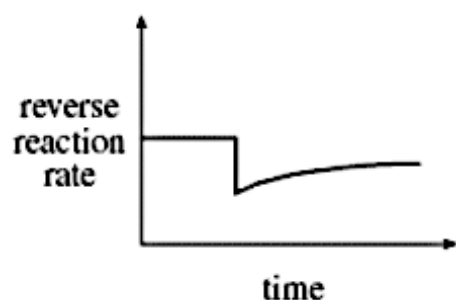
(B)



(C)



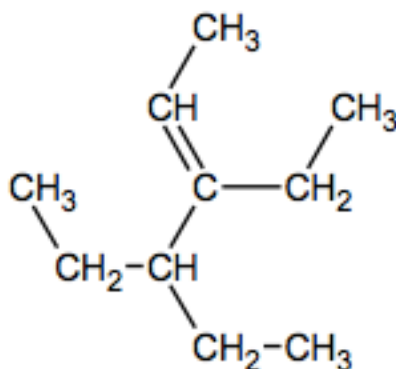
(D)



Question 3: Which of the following is not criteria of collision theory?

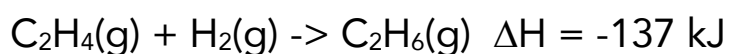
- (A) Reacting species must collide at an effective orientation
- (B) A catalyst is useful as it provides an alternative, lower energy reaction pathway for reacting species to react and form product(s).
- (C) Reacting species must collide for a reaction to take place.
- (D) The collision energy between reacting species must be greater than the activation energy of the reaction in order for a reaction to occur.

Question 4: What is the IUPAC name of the following compound?



- (A) 3,4-diethylhex-2-ene
- (B) 3-pentylpent-2-ene
- (C) 3-ethenyl-4-ethylhexane
- (D) 3,4-diethylhex-4-ene

Question 5: For the reaction



It can be said that

- (A) The total energy used to break the bonds in reactants is equal to the total energy released when the bonds are formed in the products.
- (B) The bonds broken and the bonds formed in the reaction have equal bond energies.
- (C) The total energy used to break the bonds in reactant is less than the total energy released when the bonds are formed in the products.
- (D) None of the above.

Question 6: The molar solubility of barium phosphate is 7.58×10^{-4} g/100mL of water at 25 degrees celsius. Calculate the K_{sp} for barium phosphate at the given temperature.

- (A) 3.40×10^{-23}
- (B) 5.60×10^{-23}
- (C) 4.40×10^{-23}
- (D) 8.30×10^{-22}

Question 7: The molar solubility of PbF_2 is 0.0510% (w/v) at 25 degrees celsius. Determine the K_{sp} of PbF_2 at 25 degrees celsius.

- (A) 7.2×10^{-10}
- (B) 5.7×10^{-9}
- (C) 3.6×10^{-8}
- (D) 6.5×10^{-9}

Question 8: What is the shape of C_2H_3Cl around the central carbon atoms?

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

Question 9: In decreasing melting and boiling point, which of the following is correct?

- (A) Ethanoic acid, Ethanol, ethane, fluoroethane
- (B) Ethanoic acid, Ethanol, fluoroethane, ethane
- (C) Ethanol, ethanoic acid, fluoroethane, ethane
- (D) Fluoroethane, ethane, ethanol, ethanoic acid

Question 10: How many sets of chemically equivalent protons are present in butanoic acid for Proton NMR?

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

Question 11: From start to finish, which of the following options display the correct sequential arrangement of the parts of a UV-Vis spectrophotometer?

- (A) Light source, monochromator, sample cell, detector, readout
- (B) Light source, detector, sample cell, monochromator, readout
- (C) Light source, sample cell, detector, monochromator, readout
- (D) Light source, readout, sample cell, detector, monochromator

Question 12: Which of the following is correct if there is a shift to a lower wavenumber in an IR spectrum?

- (A) A lower wavenumber on the IR spectrum corresponds to higher frequency of bond vibration.
- (B) A lower wavenumber on the IR spectrum could mean that the mass of atoms involved in the chemical bonds is higher.
- (C) A lower wavenumber could mean a shift towards lower wavelength.
- (D) A lower wavenumber must mean a decrease in peak or signal intensity.

Question 13: What is region in the electromagnetic spectrum has the wavelength of radiation between 200-400nm?

- (A) Ultraviolet
- (B) Infrared
- (C) Visible
- (D) Microwave

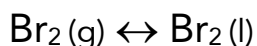
Question 14: Which of the following is incorrect about IR spectroscopy?

- (A) An unsubstituted alkene such as ethylene is infrared active.
- (B) Functional group that have similar atoms will absorb energy of the similar frequency.
- (C) The strength of the bond and the mass of the atoms involved in the infrared active bond will determine the amount of energy required to excite the molecule.
- (D) IR spectroscopy is a method that can be used to determine the structure of a molecule depending on the frequency of infrared radiation absorbed.

Question 15: Which of the following statement is incorrect in UV-Vis spectroscopy?

- (A) The absorption of UV-Vis light involves an electron making a transition from HOMO to LUMO where the energy difference between the two orbitals are equal to the energy of the UV-Vis light.
- (B) The frequency of energy in which the electron absorbs is equal to the energy difference between the HOMO and LUMO
- (C) The absorption of UV-Vis light involves an electron making a transition from LUMO to HOMO.
- (D) The absorption of UV-Vis light involves an electron making a transition from HOMO to LUMO where the energy difference between the two orbitals are equal to the frequency of the UV-Vis light.

Question 16: Which of the following K_{eq} expression is for the reaction:



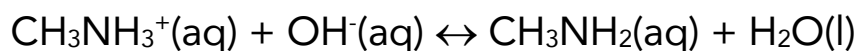
(A) $K_{eq} = \frac{\text{Br}_2(\text{l})}{\text{Br}_2(\text{g})}$

(B) $K_{eq} = \frac{\text{Br}_2(\text{g})}{\text{Br}_2(\text{l})}$

(C) $K_{eq} = \frac{1}{Br_2(g)}$

(D) $K_{eq} = [Br_{2(g)}][Br_{2(g)}]$

Question 17: For the following reaction:



The equilibrium position is most likely to lie:

- (A) on the left as water is a stronger acid than the $CH_3NH_3^+$ ion
- (B) on the left as the hydroxide ion is a stronger base than CH_3NH_2
- (C) on the right as the hydroxide ion is a stronger acid than water
- (D) on the right as the $CH_3NH_3^+$ ion is a stronger acid than water

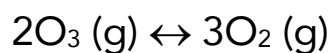
Question 18: If the forward reaction of an equilibrium reaction is exothermic, an increase in the system's temperature will result in the position of the equilibrium system to

- (A) Left and K_{eq} increases
- (B) Left and K_{eq} decreases
- (C) Right and K_{eq} increases
- (D) Right and K_{eq} increases

Question 19: In which of the following cases will a reaction not occur?

- (A) $MgCl_2(aq) + 2NaC_2H_3O_2(aq) \rightarrow Mg(C_2H_3O_2)_2(aq) + 2NaCl(aq)$
- (B) $KCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + KNO_3(aq)$
- (C) $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$
- (D) $H_2SO_4(aq) + 2NaHCO_3(aq) \rightarrow Na_2SO_4(aq) + 2H_2CO_3(aq)$

Question 20: A worker added 0.060 moles of ozone gas and 0.70 moles of oxygen gas into a one litre vessel which he closed after the adding the gases.



You are given that $K_{\text{eq}} = 55$.

Which of the following is correct as the gases move towards equilibrium?

- (A) $Q_{\text{eq}} > K_{\text{eq}}$ and the $[\text{O}_2]$ increases.
- (B) $Q_{\text{eq}} < K_{\text{eq}}$ and the $[\text{O}_2]$ increases.
- (C) $Q_{\text{eq}} > K_{\text{eq}}$ and the $[\text{O}_2]$ decreases.
- (D) $Q_{\text{eq}} < K_{\text{eq}}$ and the $[\text{O}_2]$ decreases.

SECTION II

Question 21: Describe the similarities and differences between static and dynamic equilibrium. **[5 marks]**

Question 22: Describe the development of the definition of acid and/or base over the course of history. **[5 marks]**

Question 23: Calculate the pH of the solution when 100mL of 0.1M CH_3COOH is titrated with 60mL of NaOH at 0.1M. You are given that the K_a for acetic acid is 1.8×10^{-5} . **[5 marks]**

Question 24: Calculate the initial concentration of nitrous acid given that it has an acid dissociation constant of 6.0×10^{-4} and a pH of 3.65. **[4 marks]**

Question 25: Explain the processes involved that allow the dissolution of silver chloride in water and accounting for what happens at equilibrium. **[5 marks]**

Question 26: A fellow student was performing an experiment which involved dissolved 9 grams of ammonium chloride in one litre of water. He later measured that the pH of the solution and found it to be acidic. Explain, using a chemical equation, why the resulting has a pH less than 7. **[4 marks]**

Question 27: Explain the use of analytical techniques in industry. **[4 marks]**

Question 28: Describe the differences between position isomers, chain isomers and functional group isomers. **[3 marks]**

Question 29: Explain the differences in chemical properties between unsubstituted alkanes, alkenes and alkynes in terms of bonding. **[6 marks]**

Question 30: You have performed a first-hand investigation to measure the molar enthalpy of combustion of a range of alcohols in your HSC Chemistry Course.

- (i) Describe the procedure that was used. **[4 marks]**
- (ii) Identify two safety precaution that was carried out during the experiment. **[2 marks]**
- (iii) Provide an explanation to why the calculated enthalpy of combustion deviated from the theoretical value and how you could minimise the error. **[2 mark]**

[illegible]

Question 31: Account for the differences in chemical properties between primary, secondary and tertiary alcohols. **[6 marks]**

Question 32: Compare the applications of polytetrafluoroethylene and poly(vinyl chloride) by relating to their structure and properties. **[6 marks]**

Question 33: Evaluate the economic implications arising as a result of obtaining hydrocarbons from the Earth. **[5 marks]**

Question 34: Compare the mechanism of a colourimeter against a UV-Vis spectrophotometer in determining a substance's concentration. **[4 marks]**

Question 35: You found four beakers in a laboratory and a note left by the previous worker noting that each of these beakers contain a different liquid being either cyclohexene, ethanol, cyclohexane or ethanoic acid. Explain the procedure that you would use to determine the liquid in each of the beakers. **[4 marks]**

Question 36: A student performed a redox titration where 0.0235L of potassium permanganate of unknown concentration was required to react with an acidified solution containing 0.020L of Fe^{2+} at a concentration of 0.121 moles per litre.

- (i) Write the oxidation and reduction half equations for the redox titration. **[2 marks]**
- (ii) Calculate the concentration of the KMnO_4 solution. **[4 marks]**

[illegible]

END OF EXAM

Well Done! You made it!

First, take a break. After that, you check out the following perks.

Check FULL marking criteria and sample solutions at:

<http://www.conquerhsc.com/the-hsc-cabinet/>

Discover FULL HSC Chemistry Notes (Module 5 – 8) at:

<https://www.conquerhsc.com/hsc-chemistry-syllabus-notes/>

Watch HSC Chemistry Videos on ConquerHSC's Youtube channel:

<https://www.youtube.com/channel/UCNX27mdjJXa2ocMvyEvRQfw>

Access your FREE Online Chemistry Tutor at:

<https://discord.gg/HdZUmfg>

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.

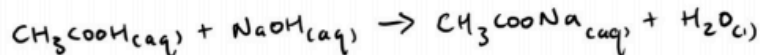
Q22 - Marking Criteria:

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)

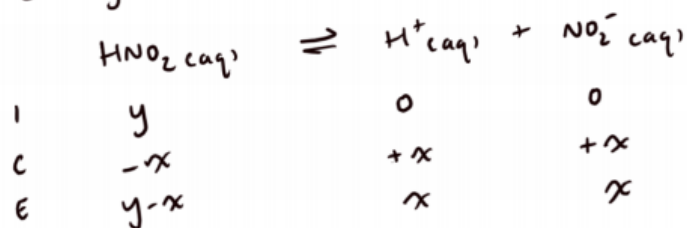
Q23 - Marking Criteria:

- 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

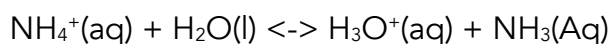
1 mark = Account for the interaction between solvent-solute molecules via ion-dipole bonds

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 accepts a proton by reacting with water and forms 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