Student number……

Hornsby Girls' High School

Trial 2021

HSC Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 180 minutes
- Write using blue or black pen
- Draw graphs, diagrams and tables using a 2B pencil
- Board-approved calculators may be used
- A Periodic Table and Data sheets are provided
- Write your student number at the top of each page
- Attempt all questions
- Answer multiple choice questions using multiple choice answer sheet
- Marks are as indicated in brackets

Total marks – 100

- **Section I Multiple Choice -20 marks**
- **Section II Written Response-80 marks**

Student number……

2021 Chemistry HGHS Section I –Multiple Choice Answer Sheet

Attempt Questions 1 –20

20 marks

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

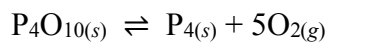
Section I Multiple Choice

Attempt Questions 1-20

Use Multiple Choice Answer Sheet for Questions 1-20

---

1. Determine the value of K_{eq} for the following reaction if the equilibrium concentrations are as follows:

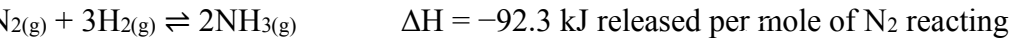


$$P_4O_{10(s)} \rightleftharpoons P_{4(s)} + 5O_{2(g)}$$

$[P_4O_{10}]_{eq} = 2.000$ moles, $[P_4]_{eq} = 3.000$ moles, $[O_2]_{eq} = 4.000$ M

A. 1024
B. 1536
C. 20
D. 4

2. The magnitude of the equilibrium constant, K_{eq}, at 25 °C for the following reaction is 640.



$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ $\Delta H = -92.3$ kJ released per mole of N_2 reacting

For the reaction $1/3\ N_{2(g)} + H_{2(g)} \rightleftharpoons 2/3\ NH_{3(g)}$, the magnitude of K_{eq} at 25 °C and the energy released per mole of H_2 reacting is

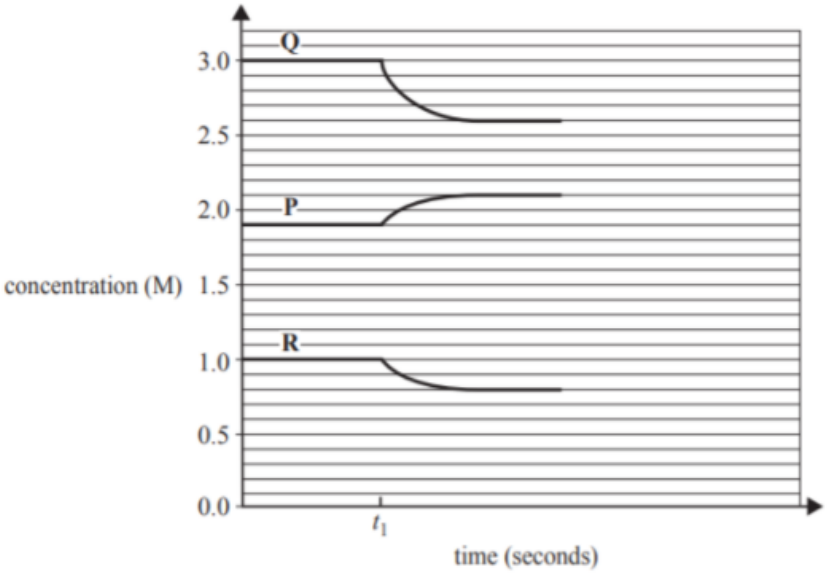
A. 9 and $\Delta H = -30.8$ kJ
B. 213 and $\Delta H = -30.8$ kJ
C. 640 and $\Delta H = -30.8$ kJ
D. 640 and $\Delta H = -92.3$ kJ

3. For the reaction 

$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ $\Delta H = -92.3$ kJ mol^{-1}

A. A catalyst increases the number of collisions between the reactants.
B. The rate of the forward reaction increases when the temperature increases.
C. A catalyst reduces the activation energy of the forward and backward reactions by the same proportion.
D. The activation energy of the forward reaction is greater than the activation energy of the reverse reaction.

4. The following concentration- time graph refers to a mixture of three gases P, Q and R in an enclosed 5.0L container. At time t_1 the mixture is heated.



The equilibrium system that represents the graph is

A. $P_{(g)} \rightleftharpoons 2Q_{(g)} + R_{(g)}$ and the forward reaction is exothermic.
B. $2Q_{(g)} \rightleftharpoons P_{(g)} + R_{(g)}$ and the forward reaction is endothermic.
C. $2Q_{(g)} + R_{(g)} \rightleftharpoons P_{(g)}$ and the forward reaction is exothermic.
D. $P_{(g)} + 2Q_{(g)} \rightleftharpoons R_{(g)}$ and the forward reaction is endothermic.

5. The following equation shows the reaction between copper and concentrated nitric acid:

$4HNO_{3(l)} + Cu_{(s)} \rightarrow Cu(NO_3)_{2(aq)} + 2NO_{2(g)} + 2H_2O_{(l)}$

Observable changes associated with this reaction are dissolving of the copper, the formation of a deep blue solution and the evolution of a pungent brown gas.

Which of the following are some of the atomic/molecular scale events needed for these observable changes to occur?

i) Collisions between HNO_3 molecules and Cu atoms
ii) Donation and acceptance of protons
iii) reduction of copper ions

A. i only
B. ii only
C. i and iii only
D. i, ii and iii

The following information is needed for Q6 and Q7.

The concentration of Vitamin C ($C_6H_8O_6$) in a filtered sample of grapefruit juice was determined by titrating the juice with 9.367 x 10^{-4} M iodine, I_2 solution (using starch solution as an indicator). The molar mass of vitamin C is 176.0 g mol^{-1}. The reaction can be represented by the following equation:

$$C_6H_8O_{6(aq)} + I_{2(aq)} \rightarrow C_6H_6O_{6(aq)} + 2H^+_{(aq)} + 2I^-_{(aq)}$$

The following method was used:

1. Weigh a clean 250 ml conical flask.
2. Use a 10 ml measuring cylinder to measure 5 ml of grapefruit juice into the conical flask and reweigh it.
3. Add 20 ml of deionized water to the conical flask.
4. Add a drop of starch solution to the conical flask.
5. Titrate the diluted grapefruit juice against the I_2 solution.

6. Which one of the following errors would result in an underestimation of the concentration of vitamin C in grapefruit juice?

   A. 19 ml of deionized water was added to the conical flask.
   B. The concentration of I_2 solution was actually 9.178 x 10^{-4} M.
   C. The initial volume of the I_2 solution in the burette was 1.50 mL but it was read as 2.50mL.
   D. The balance was faulty, and the measured mass of grapefruit juice was lower than the actual mass.

7. If the measured mass of grapefruit juice was 4.90 g and the titre was 21.50mL, what was the percentage (mass/mass) (%m/m) concentration of vitamin C in the grapefruit juice?

   A. 0.00987
   B. 0.0723
   C. 0.354
   D. 3.36

8. When 0.10 M solutions of ammonium acetate, barium acetate and potassium acetate are ranked from least basic to most basic, what is the correct ordering?

   A. $NH_4C_2H_3O_2 < KC_2H_3O_2 < Ba(C_2H_3O_2)_2$

   B. $Ba(C_2H_3O_2)_2 < NH_4C_2H_3O_2 < KC_2H_3O_2$

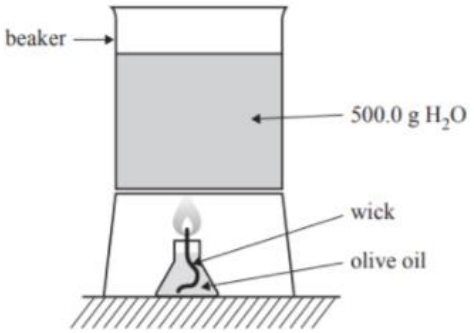
   C. $KC_2H_3O_2 < Ba(C_2H_3O_2)_2 < NH_4C_2H_3O_2$

   D. $KC_2H_3O_2 < NH_4C_2H_3O_2 < Ba(C_2H_3O)_2$

9. A solution of ammonia, NH_3, has pH = 11.50 at 25°C.
What is the ammonia concentration?
(The pK_a of NH_4^+ is 9.24.)

A. 1.7×10^{-5} M
B. 3.2×10^{-3} M
C. 5.5×10^{-3} M
D. 0.58 M

10. A sample of olive oil with a wick in a jar is ignited and used to heat a beaker containing 500.0 g of water, H_2O. The relevant data for the experiment is included in the table below.



Data

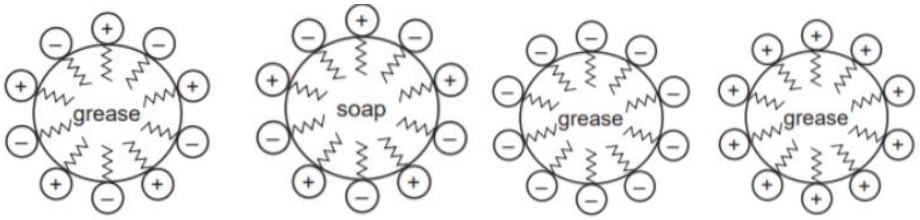
initial temperature (H_2O)	21.0 °C
ΔH (olive oil)	41.0 kJ g^{-1}
total energy lost to the environment	28.0 kJ

After complete combustion of 2.97 g of olive oil, the final temperature of the water in degrees Celsius, would be:

A. 44.9
B. 58.0
C. 65.9
D. 79.3

11. Which of the following diagrams represent the micelle that forms in water when soap is used to remove grease from dirty dishes?

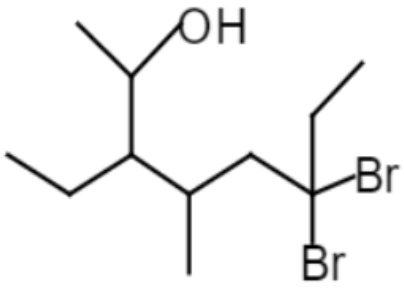
A. B. C. D.



12. A large polyethene molecule is found to have a relative molecular mass of 4.0 x10^4. The number of carbon atoms in this molecule would be closest to

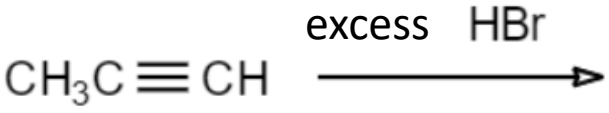
    A. 1500
    B. 2900
    C. 3300
    D. 1.8 x10^{27}

13. What is the IUPAC name of the compound shown?



    A. 3,3-dibromo-6-ethyl-5-methyl-7-octanol
    B. 6,6-dibromo-3-ethyl-4-methyl-2-octanol
    C. 5,5-dibromo-2-ethyl-1,3-dimethyl-1-heptanol
    D. 2-ethyl-1,3-dimethyl-5,5-dibromo-1-heptanol

14. What is the major organic product of the reaction shown?



    A. $BrCH_2CH_2CH_2Br$
    B. $CH_3CBr_2CH_3$
    C. $CH_3CH_2CHBr_2$
    D. $CH_3CHBrCH_2Br$

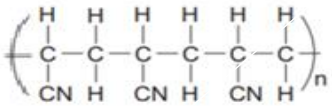
15. Which one of the following properties exhibited by octanol is not related to the dispersion forces between the molecules?

    A. Combustibility
    B. Melting point
    C. Solubility in octane
    D. Solubility in water

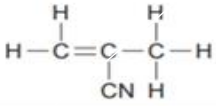
16. Which of the following alcohols would you expect to have the highest boiling point?

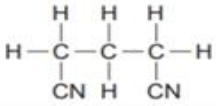
    A. Pentan-1-ol
    B. Pentan-2-ol
    C. Pentan-3-ol
    D. 2-methylbutan-2-ol

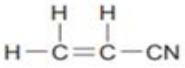
17. Polyacrylonitrile fibres can be used to make blankets and carpets. The structural formula of a segment of this polymer is shown below.

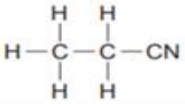


The structural formula of the monomer used to make polyacrylonitrile is:

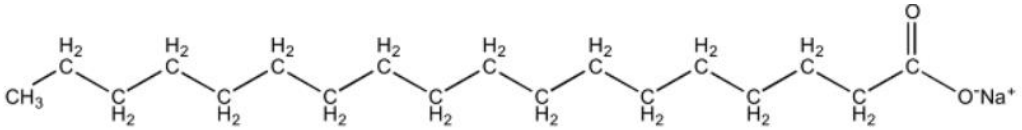
A.


B.


C.


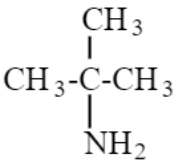
D.


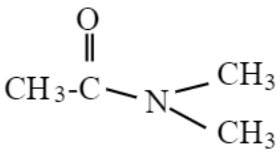
18. What type of bond would exist between this soap and oil?

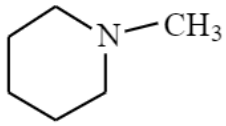


    A. Hydrogen bonds.
    B. Covalent bonds.
    C. Dipole-dipole forces.
    D. Dispersion forces

19. Which of the following is a 3° amine?

A. 

B. 

C. 

D. $CH_3(CH_2)_{12}NHCH_3$

20. Which of the following substances could not be used to form an addition polymer?

A. $ClCH_2CHCl_2$
B. CH_3CHCCl_2
C. $CH_3CH_2C(OH)CH_2$
D. C_2H_2Br2

Section II Written Responses

Attempt Questions 20-35
Answer questions in space provided. Show all relevant working.
If you require an extra writing booklet, please clearly state the number of the question you are working on.

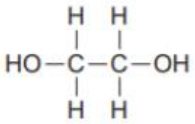
Question 21 (2 marks)

A student incorrectly named the following two compounds. Write the correct names according to the IUPAC naming system.

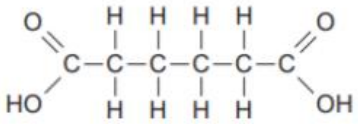
Incorrect name	IUPAC name
3,3–dimethyl–4–methylpentane	
2–ethylpropane	

Question 22 (4 marks)

Poly(ethylene adipate) is an inexpensive, biodegradable polymer. It is formed when ethylene glycol and adipic acid react. The structural formulae of these two monomers are shown below.



ethylene glycol



adipic acid

a) Draw the structural formula for the polymer poly (ethylene adipate) (2 marks)

b) Classify poly(ethylene adipate) according to the: (2 marks)

i) Functional group or groups present in its structure.

……

ii) Type of reaction resulting in its formation.

……..

Question 23 (5 marks)

a) Compound X has the formula C_4H_8O and reacts readily with $K_2Cr_2O_7$ in H_2SO_4 to yield a carboxylic acid. X is synthesised from 2-methylpropan-1-ol. What is the name and structure of X? (2 marks)

b) Butan-1-ol and 2-methylpropan-1-ol are what type of isomers? (1 mark)

……..

c) Explain how many hydrogen environments would be seen for butan-1-ol and 2-methylpropan-1-ol using ^1H Nmr. (2 mark)

……..

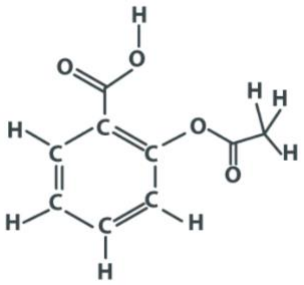
……..

……..

……..

Question 24 (12 marks)

Aspirin is called acetylsalicylic acid.



a) Write the molecular formula for aspirin (1 mark)

……

b) Name two types of functional groups in aspirin (1 mark)

……

c) The aspirin reacts with NaOH in a 1: 1 ratio write the equation for the reaction: (2 marks)

……

d) If 25.0 ml of NaOH reacts with 1.23 g of aspirin, it forms a soluble salt. What is the Molarity of the NaOH? (2 marks)

……

……

e) What indicator could be used with this acid/base reaction? (1 mark)

……

f) 1.26g of aspirin dissolves in 350 ml water. The pH is found to be 2.6. Calculate the Ka of aspirin. (5 marks)

……

……

……

……

……

……

……

……

……

……

Question 25 (4 marks)

a) Write the structural formulae for the reaction of butanoic acid and methylamine. Draw the products and name them. (2 marks)

b) Why can methylamine be considered a Brønsted–Lowry base but not an Arrhenius base? (2 marks)

……

……

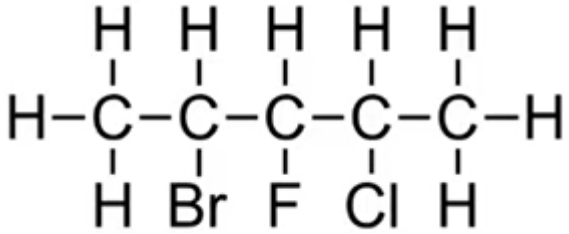
……

……

Question 26 (3 marks)

a) Name the following compound (1 mark)

……..



b) Draw 3,7-dibromo-2,7-dichloro-6-methylheptanal (1 mark)

c) Why are amides more soluble in water than amines of the same molar mass?
(1 mark)

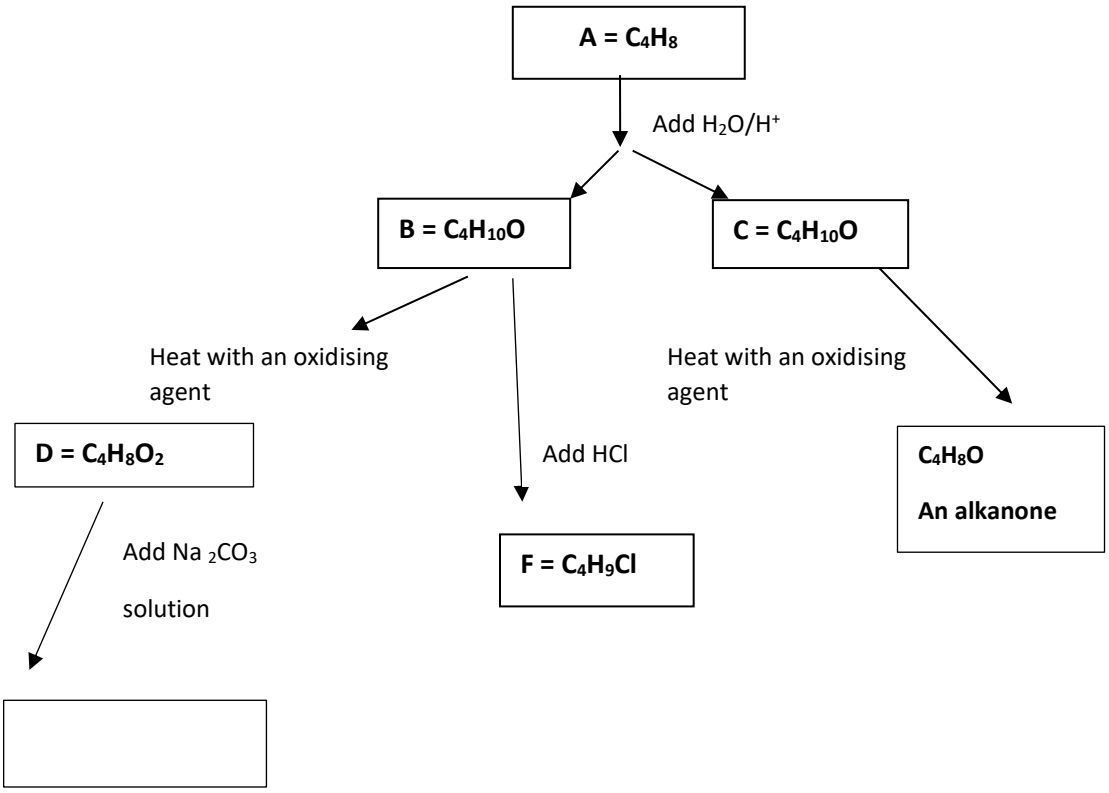
……

……

……

Question 27 (9 marks)

Use the flowchart to answer the questions below:



a) Compound **A** (straight chain molecule) reacts with dilute acid solution to form 2 different compounds with the same molecular formula, compounds **B** and **C**.

Identify compounds **A**, **B** and **C** by name and draw their structural formulae. (3 marks)

……

……

……

……

……

……

……

b) Write the balanced equation for the reaction of **D** with sodium carbonate solution. (1mark)

……

……

c) Write the equation for the reaction of **B** to form **F**. Draw the structural formula and name the organic product formed. (2 marks)

……

……

……

……

d) Draw the structural formula of the compound formed when D and C are reacted together. What conditons are needed for this reaction to occur and why? (3 marks)

……

……

……

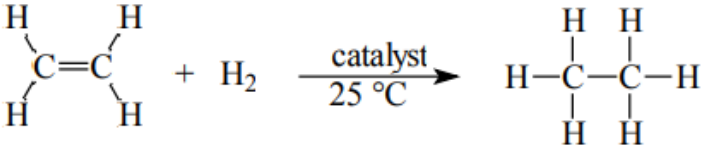
……

……

……

Question 28 (6 marks)

The following equation



ethene ethane

The Gibbs free energy value for this equation at 25°C is -125kJ/mol

a) Predict the sign of △S° for this reaction at 25°C. Explain how you came to this conclusion (2 marks)

……

……

……

……

b) Using the information above predict the sign of △H° for this reaction at 25°C. Explain briefly how you arrive at this conclusion. (2 marks)

……

……

……

……

c) Assuming the △H and △S does not change much with temperature Would this reaction reach equilibrium at Temperatures lower or higher than 25°C ? Explain why (2 marks)

……

……

……

……

Question 29 (2 marks)

Explain how Aboriginal and Torres Strait Islander peoples removed toxicity from food using equilibrium systems.

……..

……..

……..

……..

……..

…….

Question 30 (4 marks)

Aqueous succinic acid can be neutralised by aqueous sodium hydroxide:

$$(CH_2COOH)_2(aq) + 2NaOH(aq) \rightarrow (CH_2COONa)_2(aq) + 2H_2O(l)$$

This reaction can be used to determine a value for the enthalpy change of neutralisation.
The student follows this method:

1. Add 50.00 ml of 0.4000M succinic acid to a polystyrene cup.
2. Measure out 50.00 ml of 1.000M NaOH.
3. Measure the temperature of both solutions.
4. Add the NaOH to the succinic acid in the polystyrene cup, stir the mixture and record the maximum temperature.

Temperature Readings

Maximum temperature of mixture /°C	26.50
Initial temperature of mixture /°C	21.50

Calculate a value for the enthalpy of neutralisation (in $kJmol^{-1}$) for this reaction. (Assuming the density of all the solutions is the same as water and c is the same as water)

……

……

……

……

……

……

……

……

Question 31 (8 marks)

a) Calculate the pH of a buffer solution that is 0.050 M in benzoic acid (monoprotic) ($HC_7H_5O_2$) and 0.150 M in sodium benzoate ($NaC_7H_5O_2$). For benzoic acid, the $K_a = 6.5 \times 10^{-5}$ (Hint: use an ICE table). (4 marks)

……

……

……

……

……

……

……

……

b) Describe how a buffer prevents a change in pH. (2 marks)

……

……

……

……

c) Is sodium benzoate an acidic or basic salt? Explain using an equation (2 marks)

……

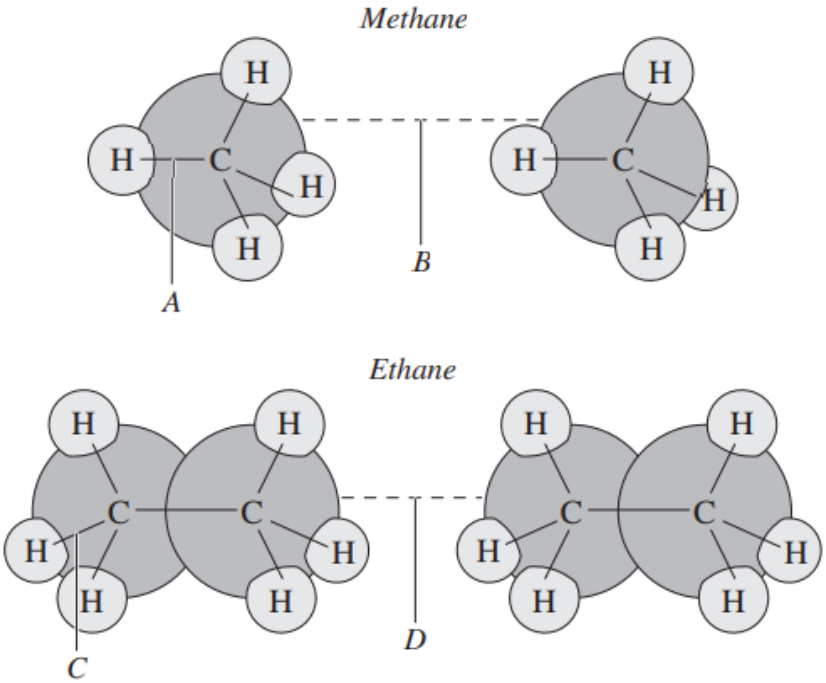
……

……

……..

Question 32 (2 marks)

The diagrams show the bonding within and between methane and ethane molecules.



Compare the strengths of bonds A and C AND compare the strengths of bonds B and D. Which type of bond determines the physical properties of the homologous series?

……

……

……

……

Question 33 (6 marks)

a) Write a net ionic equation for the reaction of solutions of barium nitrate and sodium fluoride to form solid barium fluoride. (1 mark)

……

b) Barium fluoride has $K_{sp} = 1.8 \times 10^{-7}$. What is the maximum fluoride ion concentration possible in a solution which has $[Ba^{2+}] = 5.0 \times 10^{-4}$ M? (2 marks)

……

……

……

……

c) Would a precipitate of barium fluoride form if 50 mL of 2.0×10^{-6} mol/L sodium fluoride were added to a solution of 150 mL of 5.0×10^{-3} mol/L barium nitrate? (3 marks)

……

……

……

……

……

……

Question 34 (5 marks)

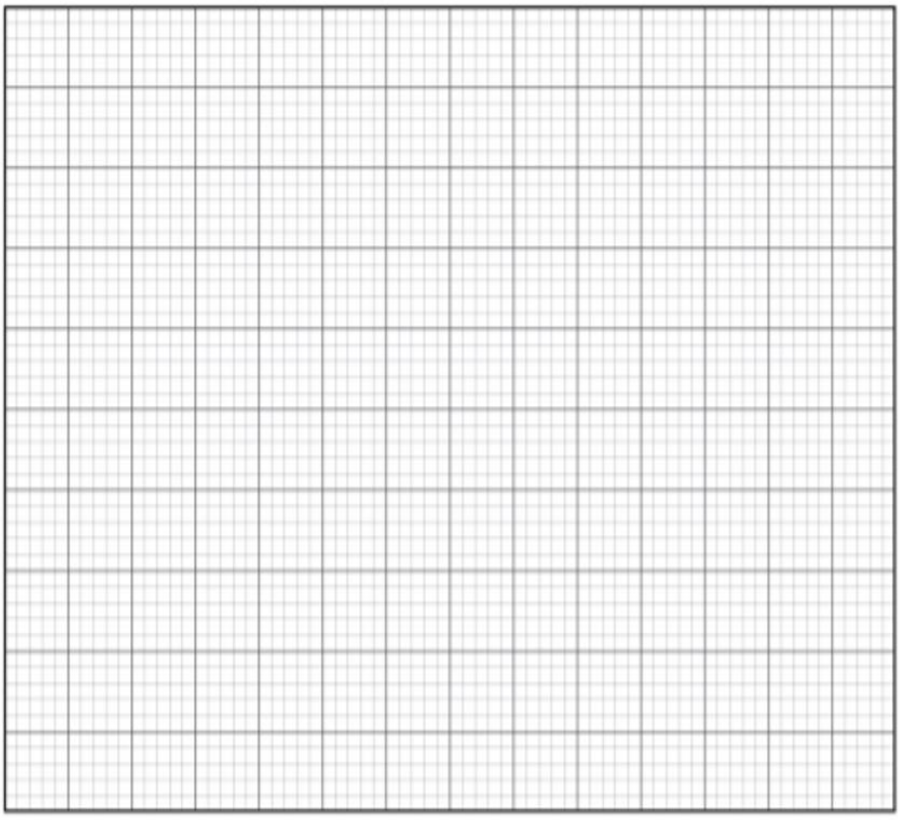
Consider the reaction between magnesium carbonate, $MgCO_{3(s)}$ and dilute nitric acid $HNO_{3(aq)}$

$$MgCO_{3(s)} + 2H^{+}_{(aq)} \rightarrow Mg^{2+}_{(aq)} + CO_{2(g)} + H_2O_{(l)}$$

The following data was obtained from the addition of excess 0.500M nitric acid to 5.00g of magnesium carbonate.

Time (min)	0	1.0	2.0	3.0	4.0	5.0	6.0
Volume of gas produced(mL)	0	12	18	25	32	33	33

a) Draw a labelled graph of the data provided in the grid below. (3 marks)



b) Explain the shape of your graph in part (a) by referring to Collision Theory. (2 marks)

……

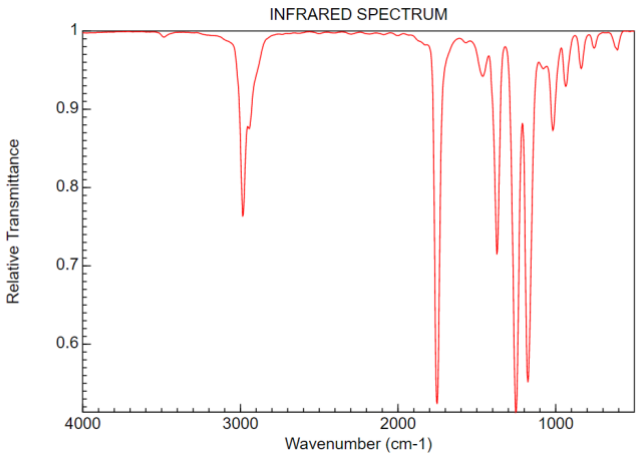
……

……

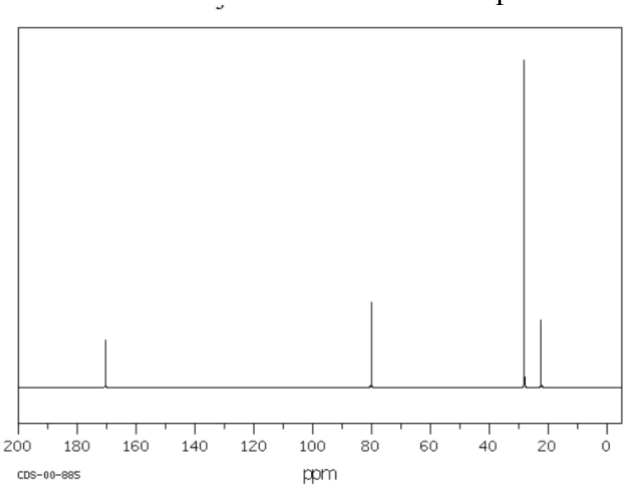
……

Question 35 (8 marks)

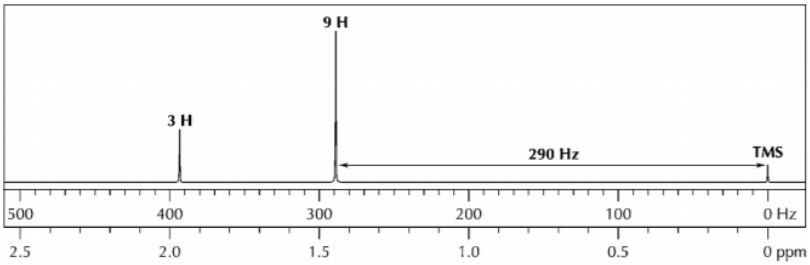
Compound X was found to have the molecular formula $C_6H_{12}O_2$. To confirm the molecular structure of the compound infrared spectroscopy, ^{13}C NMR spectroscopy and ^{1}H NMR spectroscopy were performed. The resulting spectra are shown



^{13}C NMR spectrum



^{1}H NMR spectrum



a) If a mass spectrum had been performed what value (m/z) would the molecular ion peak be? (1 mark)

……

……

b) Use the spectra provided to identify compound X. Justify your answer with reference to the data provided. (7 marks)

……

……

……

……

……

……

……

……

……

……

……

……

……