Trinity College

3AB CHEMISTRY EXAMINATION

READING TIME: **10 Minutes**
WORKING TIME: **3 Hours**

This examination is in three parts:

SECTION ONE:	25 Multiple Choice	-	25 Marks
SECTION TWO:	11 Short Answer	-	35 Marks
SECTION THREE:	4 Extended Answer	-	40 Marks

                                               — — — —
                                               100 Marks

INSTRUCTIONS:

1. Attempt ALL questions. Put your **NAME on the first page of each new answer booklet for the short answer and extended answer sections as well as on the multiple choice answer sheet.**

2. Marks will be awarded for method despite an incorrect final result <u>provided</u> working is WELL SET OUT, NEAT and LEGIBLE. You will lose marks even if the answer is correct if you have shown insufficient working.

3. A **scientific calculator** is allowed and a periodic table and data chart is supplied.

STRUCTURE OF THE PAPER

Section	No. of Questions Set	No. of Questions to be Attempted	Marks Allocated	Recommended Time (approx) in Minutes
Section1: Multiple-choice	25	25	25 (25%)	50
Section 2: Short answers	11	9	35 (35%)	60
Section 3: Extended answer	4	4	40 (40%)	70

Total Marks for Paper = 100 (100%)

INSTRUCTIONS TO CANDIDATES

Reading Time: The examiners recommend that candidates spend the reading time mainly reading the Instructions to Candidates and Sections One, Two and Three.

Section One - Multiple Choice

Answer on the separate Multiple Choice Answer Sheet.

If you consider that two or more of the alternative responses are correct, choose the one that you think is best. If you think you know an answer, mark it even if you are not certain you are correct. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

FEEL FREE TO WRITE OR DO WORKING OUT ON THE QUESTION PAPER. Many students who score high marks in the Multiple Choice Section do this.

Sections Two and Three

Use a ballpoint or ink pen. You may not answer in pencil. Write your answers in the answer books provided. You may use the ***back and front*** of the paper but make sure that **EACH NEW ANSWER BOOKLET** has your name on it.

CHEMICAL EQUATIONS

For full marks, chemical equations should refer only to those species consumed in the reaction and the new species produced. These species may be **ions** [for example $Ag^+(aq)$], **molecules** [for example $NH_3(g)$, $NH_3(aq)$, $CH_3COOH(aq)$] or **solids** [for example $BaSO_4(s)$, $Cu(s)$, $Na_2CO_3(s)$]. Phases MUST be shown in the equations for the first question of the short answer section.

Section One: Multiple-choice **25% (25 Marks)**

This section has **25** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question place a cross in the box to indicate your answer. Use only a **blue or black pen** to cross the boxes. If you make a mistake, circle the incorrect answer and place a cross in a new box.

Suggested working time: 50 minutes.

1. A student was performing a titration to determine the concentration of ammonia in a household floor cleaner. They pipetted 20 mL aliquots of floor cleaner into a conical flask and poured standardised hydrochloric acid solution into the burette. Which of the following would have caused the student's calculated ammonia concentration to be lower than it actually is?

    (a) Rinsing the pipette with water before use

    (b) Using methyl orange indicator

    (c) Rinsing the burette with water before use

    (d) Rinsing the conical flask with the floor cleaner before use

2. Which two of the following compounds may be used as primary standards in quantitative analysis?

    i)$Na_2CO_3(s)$

        ii)NaOH (s)

        iii)H_2O_2 (1)

        iv)HCl (aq)

        v)$H_2C_2O_4$ (s)

  (a)   i) and ii)

  (b)   i) and v)

 (c)   ii) and v)

  (d)   i) and iv)

3.   A student designs an electrochemical cell. One half cell consists of a nickel rod in a 1 mol L^{-1} nickel (II) sulfate solution. As the cell operates he notices that the green colour of this half cell becomes darker green. Which of the following could correctly describe the other half cell?

        I.   Chromium rod in a chromium (III) chloride solution
        II.   Copper rod in a copper (II) sulfate solution
        III.   Lead rod in a lead nitrate solution
        IV.   Zinc rod in a zinc chloride solution

  (a)   I and II

  (b)   II and III

  (c)   III and IV

  (d)   I and IV

4.   In which of the following species does platinum have the lowest oxidation number?

(a) H_2PtCl_6

(b) $NaPtCl_4$

(c) Pt_2O_3

(d) $PtCr_2O_7$

5.   In which of the following reactions is hydrogen peroxide the oxidant (oxidising agent)?

(a) $3\ H_2O_2(aq)\ +\ Cr_2O_7^{2-}(aq)\ +\ 8\ H^+(aq)\ \rightarrow\ 3\ O_2(g)\ +\ 2\ Cr^{3+}(aq)\ +\ 7H_2O(l)$

(b) $H_2O_2(aq)\ +\ Cl_2(g)\ \rightarrow\ O_2(g)\ +\ 2\ H^+(aq)\ +\ 2\ Cl^-(aq)$

(c) $3\ H_2O_2(aq)\ +\ 6\ H^+(aq)\ +\ 2\ Au(s)\ \rightarrow\ 6\ H_2O(l)\ +\ 2\ Au^{3+}(aq)$

(d) $H_2O_2(aq)\ +\ 2\ Fe^{3+}(aq)\ \rightarrow\ O_2(g)\ +\ 2\ H^+(aq)\ +\ 2\ Fe^{2+}(aq)$

6.   An electrochemical cell was set up as shown in the diagram below using two metals, X and Y, and their corresponding aqueous salts, X^{2+} and Y^{2+}.
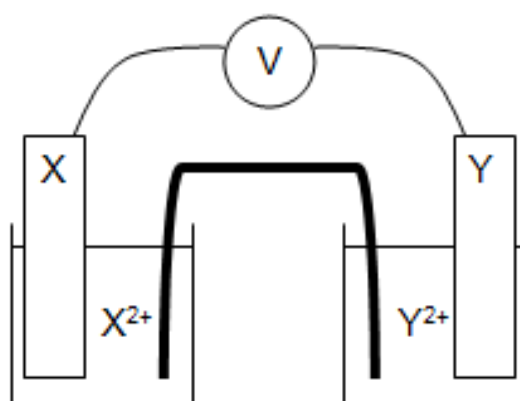
The emf was recorded to be 0.58 V. Assuming standard conditions, which pair of half-cells is most likely to have been used in the construction of this cell?

(a)   Zn / Zn^{2+} and Cu^{2+} / Cu

(b)   Ni / Ni^{2+} and Cu^{2+} / Cu

(c)   Co / Co^{2+} and Ni^{2+} / Ni

(d)   Mg / Mg^{2+} and Co^{2+} / Co

7.   A sulfate ion (SO_4^{2-}) contains the isotopes S-33 and O-15.
      How many electrons, protons and neutrons does the ion possess?

|	electrons	protons	neutrons
(a)	46	48	48
(b)	93	91	96
(c)	50	48	45
(d)	48	45	50

8.   Which of the following elemental properties do **not** have an increasing
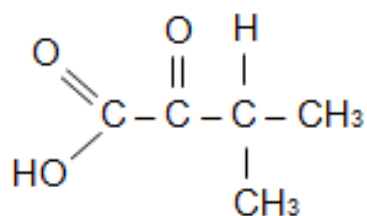   trend across Period 3 of the Periodic Table?

     I.   Atomic number
    II.   Atomic size
   III.   Electronegativity
   IV.   Ionization energy
    V.   Melting point

(a)   III and IV

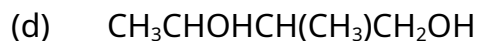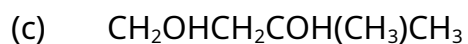(b)   I, III and IV

(c)   II and V

(d)   I, II, IV and V

9. Which of the following molecules is polar?

   (a) CH_4

   (b) $CC\ell_4$

   (c)

   (d) CO
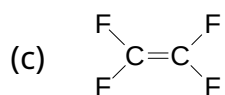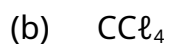
10. Consider the following molecule.

   Which of the following substances could be oxidised to form the molecule above?

    (a) $CH_3CHOHCH(CH_3)CH_3$

    (b) $CH_3CH(CH_3)CHOHCH_2OH$

    (c) $CH_2OHCH_2COH(CH_3)CH_3$

    (d) $CH_3CHOHCH(CH_3)CH_2OH$

11. Polystyrene is a polymer used in the packaging industry.
    The formula of polystyrene is $\{-CH_2CH (C_6H_5)-\}n$
    The monomer for this polymer has the molecular formula

    (a) C_8H_6

    (b) C_8H_7

    (c) C_8H_8

    (d) C_8H_9

12.   What is the systematic name for the following?
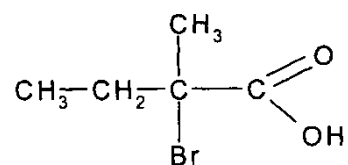
(a)   2-bromo-2-methylbutanoic acid

(b)   3-bromo-3-methylbutanoic acid

(c)   *trans*-2-pentanoic acid

(d)   *cis*-3-pentanoic acid

13.   How many of the following compounds can exhibit geometric (cis-trans) isomerism?

➢   1,1 – dibromopropene

➢   1,2 – dibromopropene

➢   2,3 – dibromopropene

➢   3,3 – dibromopropene

(a)   1

(b)   2

(c)   3

(d)   4

14.   Which of the following statements are true about the compound represented by the formula below?
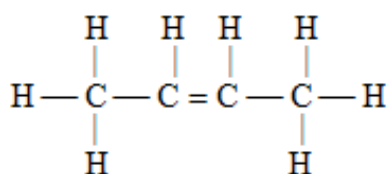
I   it is soluble in water.

II   it decolourises bromine water.

III   it undergoes addition reactions with hydrogen chloride to form two different isomers with the formula C_4H_9Cl.

IV   its systematic name is trans-2-butene.

(a)   I only.

(b)   II only.

(c)   II and III only

(d)   I, II, III and IV.

15.   For the reaction

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ}$$

Which of the following statements is **FALSE**?

(a)   reducing the volume of the container will increase the rate of reaction.

(b)   removal of $NH_3(g)$ may prevent equilibrium being achieved.

(c)   reducing the temperature will increase the rate of reaction because it's

          exothermic.

(d)   increasing the partial pressure of nitrogen gas will increase the rate of

          reaction.

16.   At room temp NO_2 (brown) exists in equilibrium with N_2O_4 (colourless).

$$2NO_{2(g)} \underset{\leftarrow}{\rightarrow} N_2O_{4(g)} \quad \Delta H = -58.2 \text{ kJ mol}^{-1}$$
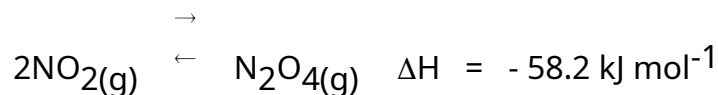
When one capsule containing an equilibrium mixture at room temperature is plunged into cold water, the intensity of the brown colour of the mixture

(a)   increases, and K increases.

(b)   decreases, and K stays the same.

(c)   decreases and K increases.

(d)   increases, and K decreases.

17. Carbon monoxide and chlorine react to form phosgene ($COCl_2$). The reaction is reversible.

$$CO \text{ (g)} + Cl_2 \text{ (g)} \rightleftharpoons COCl_2 \text{ (g)} + 35 \text{ kJ}$$
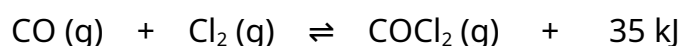
Which of the following conditions will increase the rate of formation of phosgene?

  I. Increasing the temperature

 II. Increasing the pressure

III. Removal of phosgene

IV. Decreasing the temperature

 V. Decreasing the pressure

(a)   I and II

(b)   I, II and III

(c)   III, IV and V

(d)   IV and V

18.   In which of the following is the first species acting as a base?

(a) HCO_3^- + NH_3 $\rightleftharpoons$ CO_3^{2-} + NH_4^+

(b) $H_2PO_4^-$ + HCO_3^- $\rightleftharpoons$ HPO_4^{2-} + H_2CO_3

(c) HPO_4^{2-} + NH_4^+ $\rightleftharpoons$ $H_2PO_4^-$ + NH_3

(d) SO_4^{2-} + Ba^{2+} $\rightleftharpoons$ $BaSO_4$

19.   Which of the following ions is least likely to act as a base in aqueous solution?

(a) CO_3^{2-}

(b) HPO_4^{2-}

(c) CH_3COO^-

(d) HSO_4^-

20.   Which of the following ions does not have a conjugate base?

(a) CH_3COO^-

(b) HCO_3^-

(c) NH_4^+

(d) H_3O^+

21.   Which of the following solution combinations would produce a green precipitate when mixed together?

(a)   NaCl, Ni(NO$_3$)$_3$, KCH$_3$COO, AgNO$_3$

(b)   Cr(NO$_3$)$_3$, KCl, Na$_2$CO$_3$, NH$_4$NO$_3$

(c)   NH$_4$Cl, NaCH$_3$COO, Ni(NO$_3$)$_2$, FeCl$_2$

(d)   CuSO$_4$, NaNO$_3$, KCH$_3$COO, CrCl$_3$

22.   The pH of water at 25 °C is 7, whereas the pH of boiling water is 6.14. This is due to the endothermic self-ionisation of water.

$$H_2O \text{ (l)} + H_2O \text{ (l)} \rightleftarrows H_3O^+ \text{ (aq)} + OH^- \text{ (aq)}$$
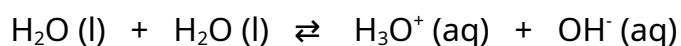
Which of the statements below is correct?

(a)   Boiling water has a higher concentration of hydronium ions present

(b)   Boiling water has a lower concentration of hydroxide ions present

(c)   Boiling water is more acidic

(d)   The pH of boiling water cannot be reliably measured

23.   A very good rocket propellant can he made by allowing hydrogen and fluorine   to react. They are light in mass and produce a greater amount of energy per   unit mass than any other chemical fuel.

The potential energy diagram for the following reaction is shown below :

$$H_2(g) + F_2(g) \rightleftarrows 2 HF(g)$$
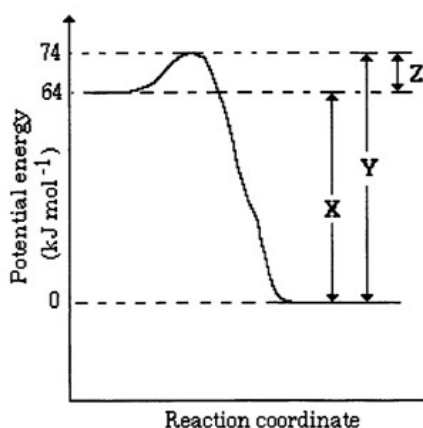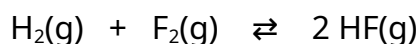
Raising the temperature of the system would initially :

(a) increase only the rate of the forward reaction.

(b) decrease only the rate of the reverse reaction.

(c) increase the rate of the forward reaction and decrease the rate of the reverse reaction.

(d) increase the rate of the reverse reaction more than it would increase the rate of the forward reaction.

24. Which of the following gases would occupy the largest volume?

(a) 0.10 mol of CO_2 at 50°C and 1.0 kPa pressure

(b) 0.10 mol of H_2 at 40°C and 1.0 kPa pressure

(c) 0.20 mol of CH_4 at 50°C and 1.0 kPa pressure

(d) 0.10 mol of O_2 at 50°C and 0.40 kPa pressure

25. When 40 mL of 1.0 mol L^{-1} $BaCl_2$ solution is added to 10 mL of 2.0 mol L^{-1} K_2SO_4 solution, the amount in mole of $BaSO_4$ precipitate formed is:

(a) 1.0 mol

(b) 0.020 mol

(c) 0.040 mol

(d) 0.060 mol

END OF SECTION ONE

Section Two: Short answer **35% (35 Marks)**

This section has **11** questions. Answer **ALL** questions. Write your answers in the answer book provided.

Suggested working time: 60 minutes.

1. Write balanced **ionic equations** and **full observations** for reactions that occur, **if any**, in the following experiments. You **MUST** use ionic equations. In your observations describe any colour change, precipitate (give colour) or gas evolution (colour and odour), resulting from the chemical reaction. In cases where you feel that no reaction is possible you must **state** this and describe the reactants that will not change!

   (a) Small pieces of magnesium metal are added to a beaker containing 0.4M ethanoic acid solution.

   (b) Acidified potasssium permanganate solution is added dropwise to propanal.

   (4 marks)

2. Draw the electron - dot diagrams for the following species:

(a) Sodium Bicarbonate ($NaHCO_3$)
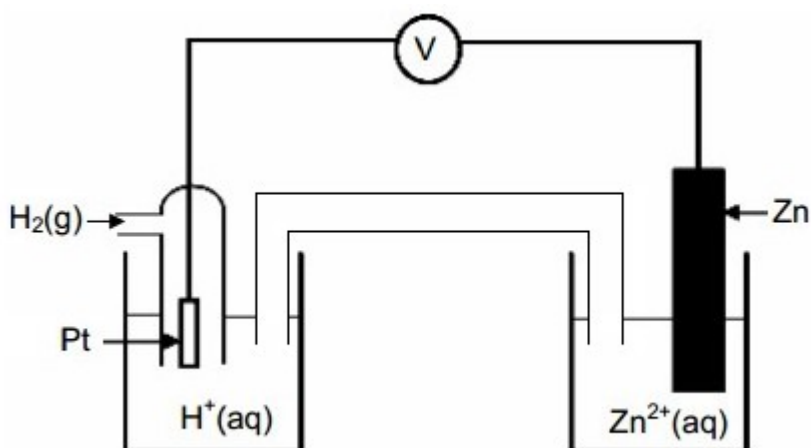
(b) $CH_2ClNH_3^+$ ion

(2 marks)

3. Methane reacts with fluorine to form four different fluorinated compounds.

Write the formulas of all the fluorinated methanes that are **polar**. If the molecule is not polar do not write its formula as you will be penalised marks.

(2 marks)

4. This question refers to the following cell diagram:

(a) What is the anode half-cell reaction?

(b) What is the cathode half-cell reaction?

(c) What is the cell E.M.F.?

(d)   What is the significance of the left hand half-cell?

(e)   What is the reducing agent in this cell reaction?

(f)   Why was a platinum electrode chosen for the left hand half-cell?

(g)   Had sodium carbonate been chosen as the salt-bridge electrolyte there   would be the potential for side reactions to have occurred in the salt-   bridge or the solutions in the beakers. List **two** possible products of   these side reactions.
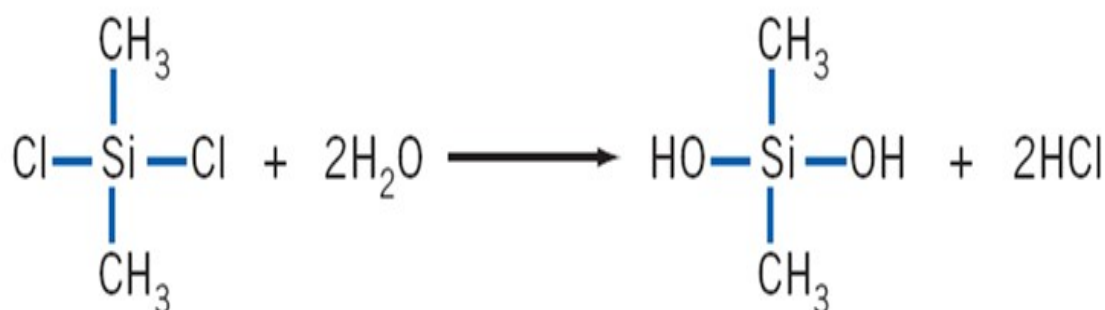
(4 marks)

5.   **DRAW** and **NAME** the principal **ORGANIC** molecule formed in the following reactions under appropriate conditions:
You must show "H" for the position of all hydrogens!

(a)   Propanoic acid and methanol.

(b)   Ethanol and limited dilute acidified potassium dichromate solution.

(c)   Ethene and hydrogen chloride.

(d)   Benzene and bromine.

(4 marks)

6.   Silicone polymers are made by reacting chlorosilanes with water to form silanols as shown below:

$$CH_3 \qquad\qquad\qquad CH_3$$
$$| \qquad\qquad\qquad\qquad |$$
$$Cl-Si-Cl + 2H_2O \longrightarrow HO-Si-OH + 2HCl$$
$$| \qquad\qquad\qquad\qquad |$$
$$CH_3 \qquad\qquad\qquad CH_3$$

The silanols may then be dehydrated under certain conditions and will link to form silicone polymers.

(a) Why is the silicon containing product called a 'silanol'?

(b) Draw **either** a **dimer** or the **smallest repeating unit** of a silicone polymer.

(c) The structure of the polyamide polymer 'nylon 6,6' is given below:
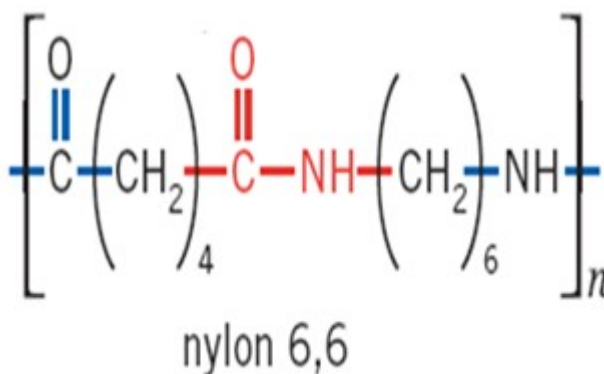
nylon 6,6

Explain in a sentence or two why 'nylon 6,6' would be a solid at room temperature whereas the silicone that you have drawn in part (b) is a liquid.

(4 marks)

7.   The compound shown below gives cinnamon its characteristic flavour and
      odour. It is a pale yellow liquid that occurs naturally in the bark of
cinnamon   trees.
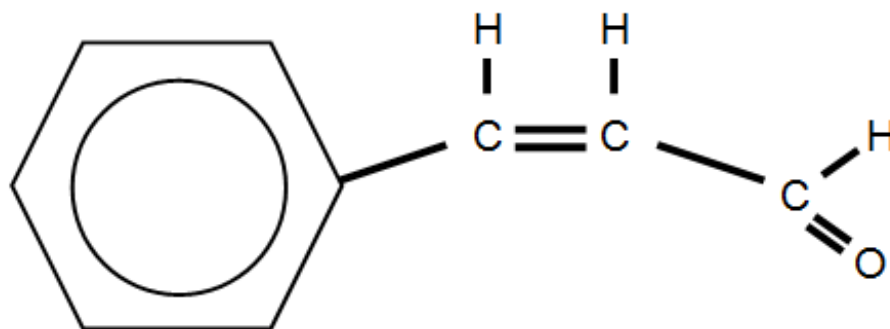
(a)   **Name** the **two** main two functional groups present in the molecule.

(b)   **Draw** the structure of the product that would be formed if the
       compound above was mixed with some liquid bromine.

(c)   **Draw** the structure of the product that would be formed if the
       original compound above was mixed with an acidified solution of
              potassium permanganate.

(d)   **Draw** the structure of the product that would be formed if the
original   compound above was polymerized in the presence of an
appropriate catalyst such as ultraviolet light. You should show **either** a
dimer or the   *smallest repeating unit* of the polymer in your answer.

NB: *You may wish to alter bond angles in the original molecule to make
       your task in part (d) easier.*

   (4 marks)

8.   A chromate/dichromate equilibrium can be represented as shown below:

$$Cr_2O_7^{-2}{}_{(aq)} + H_2O_{(l)} \leftrightarrow 2CrO_4^{-2}{}_{(aq)} + 2H^+{}_{(aq)}$$
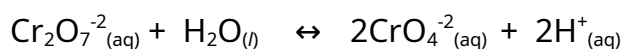
Given that a sample solution is initially orange in colour, describe what you would observe upon the addition of sodium hydroxide solution. Explain this observation using appropriate equations **and** Le Chatelier's Principle.

(2 marks)

9.   Universal indicator was used to measure the pH of six solutions (each with
a   concentration of 0.5 mol L^{-1}) and the results are shown in the diagram
below.
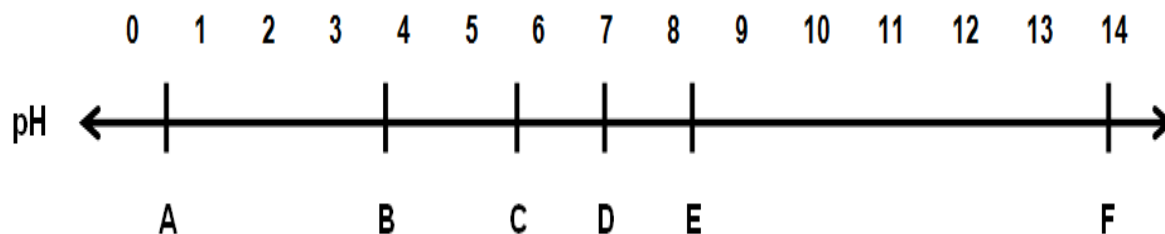
The six substances were;

   KCl   HF   HCl   NH$_4$Cl   KOH   KF
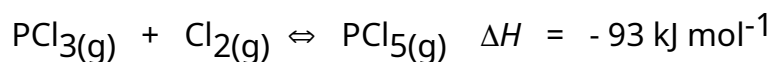
(a)   Which substance is most likely to be C? Explain your answer using
an   equation.

(b)   Which substance is most likely to be F? Explain your answer using
an   equation.
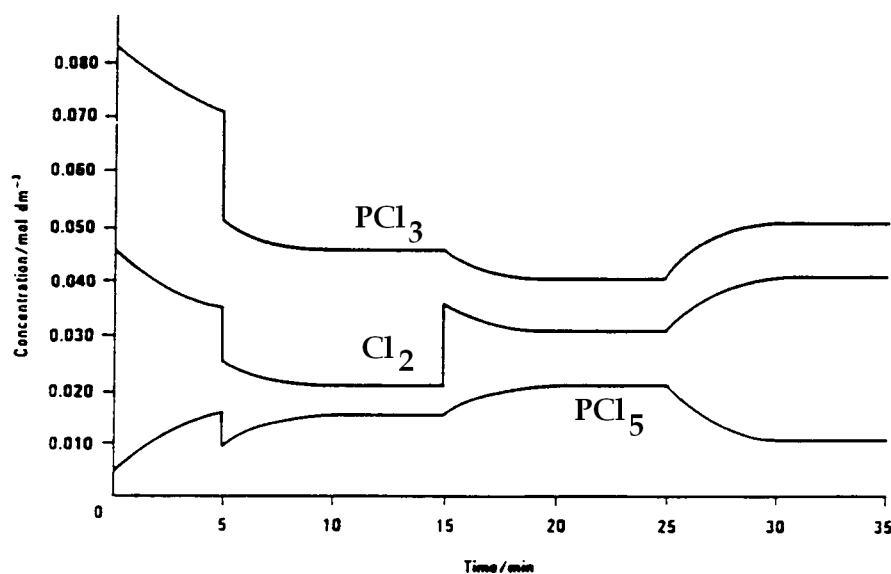
     (c)   Name the two substances that would produce a buffer when mixed together.

                                                           (4 marks)

10.   The concentrations of the three substances in the reaction:

$$PCl_{3(g)} + Cl_{2(g)} \rightleftharpoons PCl_{5(g)} \quad \Delta H = -93 \text{ kJ mol}^{-1}$$

are shown in the graph below:

     (a)   Suggest what might have been done to the system at the 5 minute mark before it has come to equilibrium.

     (b)   Account for the horizontal section of the graph between the 20 and 25

            minute marks.

     (c)   Suggest what may have been done to the system at the 15 minute mark?

     (d)   Suggest a change that could have been made to the system to bring about the changes after the 25 minute mark.

(e)   How would the addition of a catalyst at the 5 minute mark have affected the shape of the curve between the 5 and 15 minute marks?

(f)   Describe fully in terms of Le Chatelier's principle the affect that injecting more $PCl_{5(g)}$ would have on the system at any time that it was in equilibrium, making sure to detail the new relative concentrations of each of the component gases when equilibrium is re-established.

(4 marks)

11.   Acid base titrations may be categorized according the strength of the acid
or   base being titrated against each other. In your course you have studied
three major categories:

(i)   STRONG ACID v STRONG BASE (**SA v SB**)

(ii)   STRONG ACID v WEAK BASE   (**SA v WB**)

(iii)   STRONG BASE v WEAK ACID   (**SB v WA**)

Titration curves for two typical titrations are given below. Decide which category of titration is represented correctly by each curve. You need
simply   to state the category (you may use the abbreviations above) for
each.

(a)

(b)

Volume of acid added (mL)
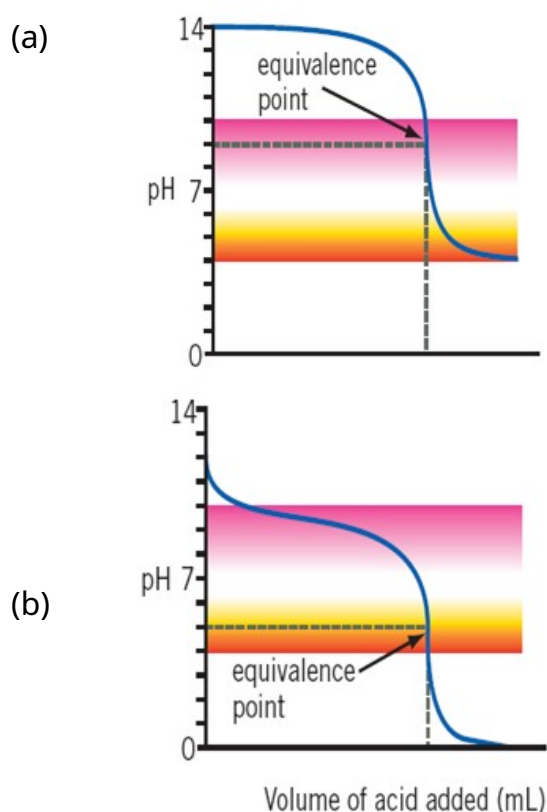
(1 mark)

END OF SECTION TWO

Section Three: Extended answer   **40% (40 Marks)**

This section contains **four (4)** questions. You must answer **ALL** questions. Write your answers in the answer book provided.

Any calculations are to be set out **in detail** on the paper provided. You may be penalized significantly for failure to show appropriate working, even if you obtain the correct numerical answer. Marks will be allocated for correct equations and clear setting out of a partial answer, even if you cannot complete the problem. This part carries **40 marks**.
 Numerical answers **MUST** be corrected to **THREE (3) SIGNIFICANT FIGURES**.

Suggested working time: 70 minutes.

1.   Aspirin is a drug commonly used to reduce inflammation and to relieve pain.
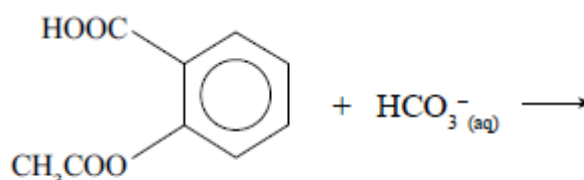   The molecular structure of aspirin is given below:
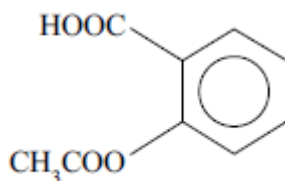
        (a)   What two major functional groups does this molecule contain?

(1 mark)

(b)   What is the empirical formula of aspirin?

(1 mark)

(c)   Aspirin is often taken in ionic form. The ionic form is achieved by
       reacting this monoprotic molecular form with bicarbonate
ions. The   reactants in an ionic equation are represented below:

What are the **three** products of this reaction?
You may answer by either giving the chemical formula or drawing
the   molecular structure of the products depending on which is easier
and   most appropriate.

(2 marks)

(d)   Explain in a paragraph why the ionic form is more soluble in water
than   the molecular form.

(3 marks)

(e)   A patient is studied to determine the amount of Aspirin that is
       absorbed in his stomach. On one particular day of the study his
stomach   pH level is determined to be 2.1.
       Calculate the concentration of hydrogen ions in his stomach.

(1 mark)

(f)   In the stomach the ionic form of aspirin is in equilibrium with the
       molecular form as shown in the diagram below:

molecular form
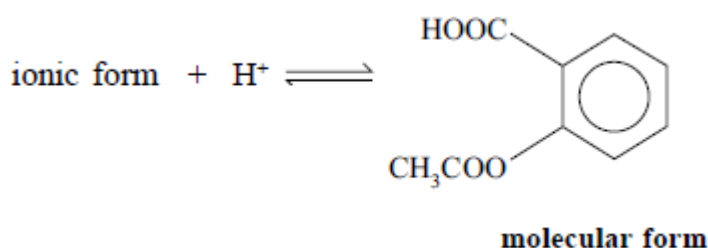
State and **explain**, in terms of the equilibrium above using Le Chatelier's principle, which form of aspirin will be present in higher concentration in the stomach. You should answer in three or four sentences only.

(3 marks)

(g)   On another day the study patient is suffering from indigestion or heartburn which can be caused by excess acid in the stomach. It is decided that the **excess** stomach acid should be treated with an antacid tablet. Bicarbonate of soda ($NaHCO_3$) is the main constituent of indigestion tablets which are used to neutralise excess stomach acid (HCl) according to the equation:

$$NaHCO_3 \text{ (aq)} + HCl \text{ (aq)} \rightarrow NaCl \text{ (aq)} + H_2O \text{ (l)} + CO_2 \text{ (g)}$$

A particular indigestion tablet weighs 3.0 g and 70% of this tablet (by mass) is $NaHCO_3$. If two tablets exactly are required to neutralise the excess stomach acid,

(i)   calculate this mass of excess HCl produced by the patient.

(ii)   calculate the pH of the aqueous stomach contents prior to treatment with antacid given that the volume of excess acid solution neutralised in part (i) was 35mL.

(4 marks)

2.   An organic compound is known to contain the elements carbon, hydrogen, nitrogen and oxygen. Combustion of a 6.922g sample of this compound yields 11.83g of carbon dioxide and 5.442g of water, the mixture of nitrogen oxides was not analysed. A further 6.922g sample of the compound was found to contain a percentage mass of Nitrogen of 13.59%

(a)   Calculate the mass of nitrogen in the 6.922g sample.

(0.5 mark)

(b)   Calculate the empirical formula of the compound.

(5 marks)

(c)   Given that the molecular weight is 103.112 g.mol^{-1} determine the molecular formula.

(0.5 marks)

(d)   Given that the molecule is an alpha-amino acid give a possible molecular structure **and** the I.U.P.A.C. name for the amino acid molecule.

(2 marks)

(e)   The material produced was found to polymerise with the amino
acid   glycine, which has the formula;
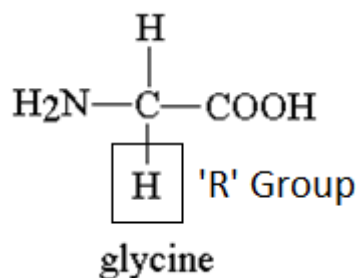

glycine

     Rearrange the amino acid from part (d) so that its formula has the same   relative appearance as that of glycine above with the 'R' group pointing   down the page and then show a dimer (linked group of two monomers   only) of the amino acid from part (d) and glycine. Once you have done   this **circle the peptide linkage**.

(1.5 marks)

(f)   Draw the zwitterion of glycine formed in near neutral pH solutions.

(1 mark)

3.   Benzene (C_6H_6) can be produced by the dehydrogenation of cyclohexane (C_6H_{12}) gas. The reaction has a high activation energy (880 kJ mol^{-1}), is also endothermic and reversible. The cyclohexane (C_6H_{12}) passes through a special reaction tower where hydrogen is chemically removed. The benzene/cyclohexane/hydrogen mixture then passes through a compressor, where the benzene is liquefied. A special membrane in the compressor allows the small hydrogen molecules to pass through, and out. The unreacted cyclohexane (C_6H_{12}) gas is then returned to the reaction tower.

$$C_6H_{12} \text{ (g)} + 120 \text{ kJ} \rightleftharpoons C_6H_6 \text{ (g)} + 3 H_2 \text{ (g)}$$
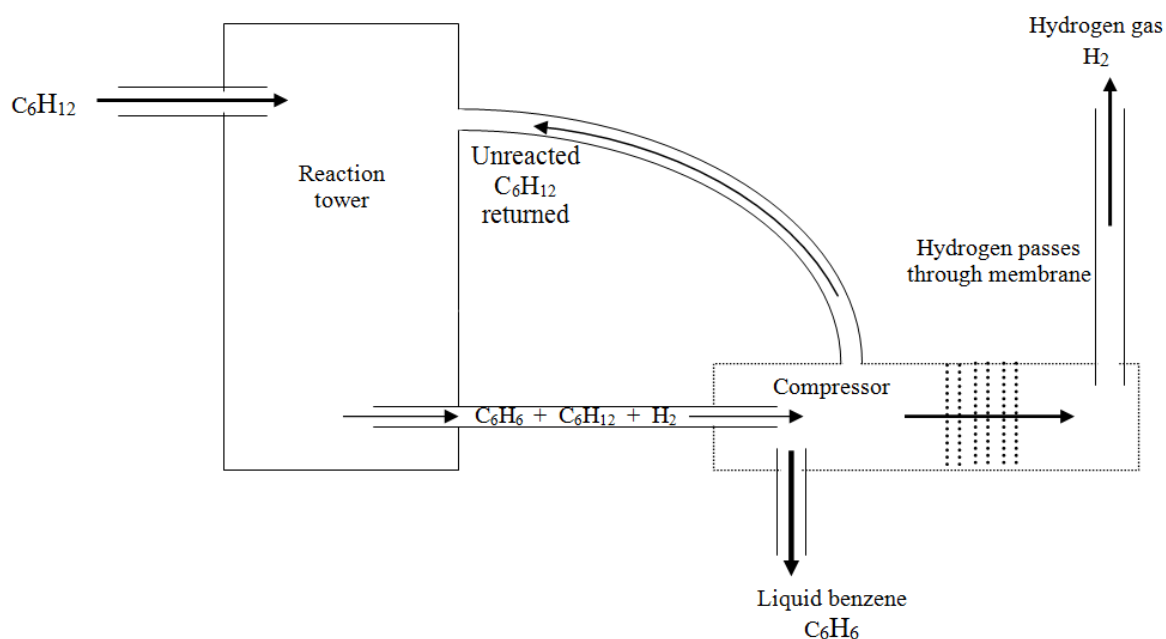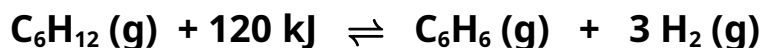
(a)   Draw a labeled energy profile diagram for the reaction that is **roughly** **to scale** and indicates clearly the **actual reactant** and **product** particles   and their relative energy. You must also show the **activated complex**,   **activation energy** for the **forward and reverse** reaction as well as the   **ΔH of reaction**, make sure to indicate the **sign and value of your ΔH**   when you show it on the graph.

(3 marks)

(b)   Write an equilibrium constant expression for the reaction.

(0.5 marks)

(c)   Under what environmental conditions will the **rate** of the forward   reaction be greatest?

(1 mark)

(d) How does the liquefaction of the benzene assist the yield achieved in the reaction tower?

(1 mark)

(e) Suggest conditions of temperature and pressure that would be used for the commercial production of benzene using this process.

Explain why you chose these conditions making reference to Le Chatelier's principle.

(4 marks)

4. Scott was entrusted to housesit for his parents whilst they were on an overseas holiday. The day before they were due to come home he noticed a large green stain on the brand new carpet. Being a chemist he realised that he needed a cleaner that was at least 4.00% ammonia (NH_3) by mass, as this was a particularly stubborn stain to remove. With time being of the essence he decided to analyse his new commercial brand of cleaner known as "cloudy ammonia" to see if it would be up to the task.

14.928g of "cloudy ammonia" cleaner was placed in a 250mL volumetric flask and made up to the mark. 25.0mL aliquots of this solution required, on average, 22.8mL of 0.128 $mol.L^{-1}$ H_2SO_4 for neutralisation. Calculate the percentage of ammonia by mass in Scott's new floor cleaner.

(4 marks)

END OF SECTION THREE
END OF PAPER