## SECTION A (CGCEB 2016)

### General and Physical Chemistry

1. (a) (i) Define the second ionisation energy of fluorine

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(ii) Write an equation to represent the second ionisation energy of fluorine

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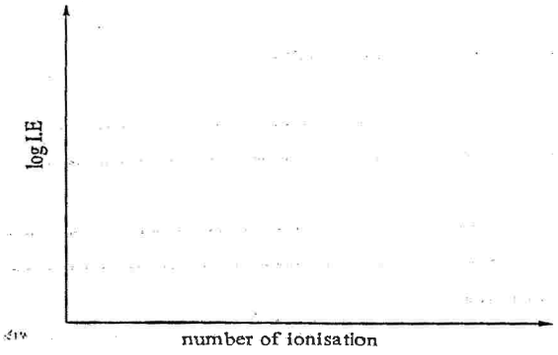
(iii) Using the axis below, sketch a graph to show the successive ionisation energies of fluorine




(iv) Give reasons for the shape of your graph

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**6 marks**

(b) (i) Draw the "dot and cross" diagram of carbonic acid $H_2CO_3$.

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(ii) Draw the resonance structures of the $HCO_3^-$ anion.

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(iii) Complete the table below by stating the molecular shapes and bond angles of the following species.

| Species | Molecular shape | Bond angles |
|---|---|---|
| $CF_4$ | | |
| $NF_3$ | | |
| $CH_2Cl_2$ | | |
| $H_3O^+$ | | |

**7 marks**

(c) The following reaction occurs at 450°C. $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$

| Experiment | Initial $[H_2]$mol $dm^{-3}$ | Initial $[I_2]$mol $dm^{-3}$ | Initial rate of production of HI mol $dm^{-3}s^{-1}$ |
|---|---|---|---|
| 1 | 0.0113 | 0.0011 | $1.9 \times 10^{-23}$. |
| 2 | 0.0220 | 0.0033 | $1.1 \times 10^{-22}$ |
| 3 | 0.0550 | 0.0011 | $9.3 \times 10^{-23}$ |
| 4 | 0.0220 | 0.0056 | $1.9 \times 10^{-22}$ |

(i) Determine the order of the reaction with respect to $H_2$ and $I_2$.

(A) Order with respect to $H_2$

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(B) Order with respect to $I_2$

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(ii) What is the overall order of the reaction?

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(iii) Write an expression for the rate law.

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(iv) Determine the value of the rate constant and state its units.

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--- **7 marks**

2. (a) (i) Explain how positive and negative deviations from Raoult's law arise when liquids are mixed.

Negative deviation ----------

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Positive deviation----------

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(ii) If a solution shows positive deviation from Raoult's law, would you expect it to have a higher or lower boiling point? Explain ----------

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4 marks

(b) (i) Define the "mole of a substance" ----------

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(ii) How many moles of carbon atoms are there in 1.0 mole of sucrose, $C_{12}H_{22}O_{11}$?
(RAM H=1.0, C=12.0, O=16.0) ----------

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(iii) How many carbon atoms are there in 1.0 mole of sucrose? (Avogadro's number= $6.022 \times 10^{23}$)

3 marks

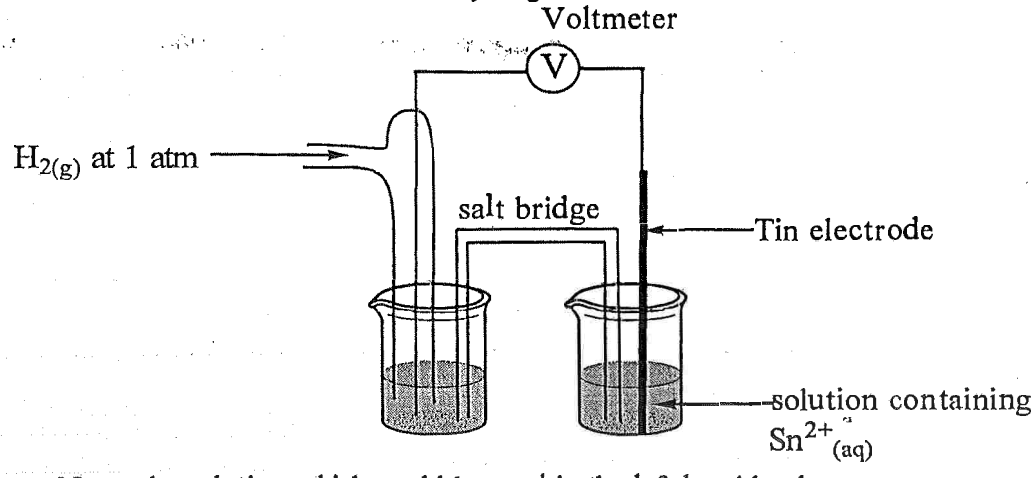
(c) (i) Define "lattice energy" ----------

(ii) Draw the Bond-Haber cycle for NaCl and use the data below to calculate its lattice energy.

| Reaction | $\Delta H^{\emptyset}(KJ)$ |
|---|---|
| $Na_{(s)} \rightarrow Na_{(g)}$ | +109 |
| $Cl_{2(g)} \rightarrow 2Cl_{(g)}$ | +243 |
| $Na_{(g)} \rightarrow Na^{+}_{(g)} + e^{-}$ | +496 |
| $Cl_{(g)} + e^{-} \rightarrow Cl^{-}_{(g)}$ | −34·9 |
| $Na_{(s)} + {}^{1}/_{2}\, Cl_{2(g)} \rightarrow NaCl_{(s)}$ | −411 |

10 marks

(d) A student measuring standard electrode potentials had the following set up in which he connected a half-cell -to a standard hydrogen electrode.




(i) Name the solution which could be used in the left-hand beaker----------

(ii) Suggest a solution that is suitable for the salt bridge ----------

(iii) Write the cell diagram for the arrangement above. ----------

3 marks

## SECTION B (CGCEB 2016)

**Inorganic (Mineral) Chemistry**

3. (a) (i) Write the outer electron configuration of the halogens ----------

(ii) State and explain how the following properties will vary down the group 17 (Group VII) of the periodic table.

(A) Volatility ----------

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(B) Electropositivity ----------

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5 marks

(b) A solution of chlorine in water is used as a disinfectant. The following chemical equation indicates the reaction between water and chlorine

$Cl_{2(g)} + H_2O_{(l)} \rightarrow Cl^-_{(aq)} + ClO^-_{(aq)} + 2H^+_{(aq)}$

(i) Give a balanced equation for the reaction that occurs when a concentrated solution of NaOH is added to this medium ----------

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(ii) What name is given to this type of reaction? ----------

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*2 marks*

(c) (i) Write balanced equations for the preparation of HF and HI from $CaF_2$ and NaI respectively.

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(ii) Explain any similarity or difference in the methods of preparation of HF and HI -------

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**3 marks**

(d) Nitric acid is manufactured by the catalytic oxidation of ammonia.

(i) Name the source of ammonia used in this process ----------

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(ii) Write a balanced equation for the oxidation of ammonia to nitrogen monoxide ---------

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(iii) Suggest the temperature at which the reaction in d(ii) occurred as well as the name of the catalyst that was used. ----------

(iv) Write an equation for the conversion of $NO_2$ to $HNO_3$ ----------

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**5 marks**

(e) Sulphuric acid is prepared from sulphur dioxide through the reaction

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(i) Why is the pressure of one atmosphere maintained taking into consideration that increasing the pressure will favour the production of more $SO_3(g)$?----------

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(ii) Which catalyst is used in the process? ----------

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2 marks

(f) A large amount of sulphur dioxide was released into the air during the Lake Nyos disaster.

(i) Write an equation to show how $SO_{2(g)}$ reacts with water ----------

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(ii) What is observed when $SO_{2(g)}$ is bubbled through solutions of $Fe^{3+}$ and $MnO_4^-$ ions?

(A) $Fe^{3+}$ ion ----------

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(B) $MnO_4^-$ ion----------

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3 marks

4. Define

(a) (i) d-block element ----------

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(ii) Transition metal ----------

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(b) (i) Write down the "electron-in-box" configuration of the $Fe^{2+}$ and $Fe^{3+}$ ions (atomic number=26)

$Fe^{2+}$ ion----------

$Fe^{3+}$ ion----------

(ii) Which ion is more stable and why? ----------

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4 marks

(c) State and explain the variation in the following properties across the first transition series (scandium to zinc)

(i) First ionisation energy ----------

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(ii) Atomic radius ----------

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4 marks

(d) The elements of period 2 of the Periodic Table include Lithium to Neon.

(i) Complete the table below by giving the formula of the stable oxide of the element.

| Element | Li | Be | B | C | N | O | F | Ne |
|---|---|---|---|---|---|---|---|---|
| Formula of oxide | | | | | | | | |

(ii) Identify the element whose oxide is

(A) Most basic ----------

(B) Most acidic ----------

(C) Amphoteric ----------

3 marks

(iii) Sketch the graph of the first ionisation energy versus atomic number for the elements across the period ----------

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3 marks

(iv) Write equations for the reaction of the oxide of Be and the oxide of B with water.

(A) Oxide of Be ----------

(B) Oxide of B ----------

----------2 marks

## SECTION B (CGCEB 2016)

**Organic Chemistry**

5. (a) A sample of aspirin (acetylsalicyclic acid) of molecular weight 180, on analysis was found to contain 60% carbon, 4.4 % hydrogen and 35.6% oxygen (RAM: C = 12, H = 1, O = 16).

(i) Determine the empirical formula of aspirin? ----------

(ii) What is the molecular formula of aspirin? ----------

(iii) State the technique that can be used to determine the molecular weight of aspirin ------

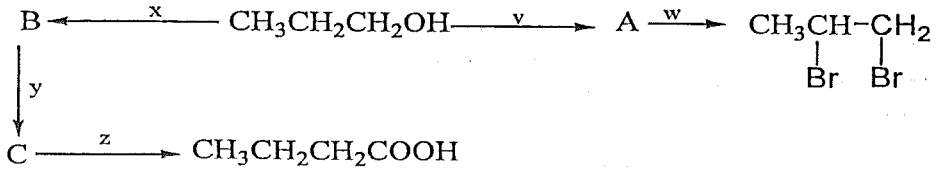
5 marks

(b) (i) Give the structures of all the isomers of a compound with molecular formula $C_3H_6Cl_2$ ----------

(ii) Which structure(s) in 5b(i) is (are) optically active? ----------

5 marks

(c) Study the reaction scheme shown below.




(i) Give the structural formula of

A ----------

B ----------

C ----------

(ii) Give the reagent(s) and reaction conditions for steps labelled v-z.

v ----------

w ----------

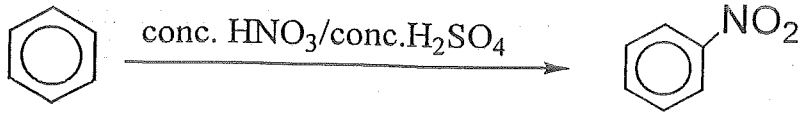
x ----------

y ----------

z ---------- 8 marks

(d) Name the mechanism associated with each of the following reactions.

(i) $CH_3CH_3 \xrightarrow{\text{uv light}} CH_3CH_2Cl$

(ii) 

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2 marks

6. (a) Give the systematic name of the following compounds

(i) $CH_3CHFCCl_2CH_2OH$ ----------

(ii) $CH_3CH(CH_3)CH_2CHO$ ----------

(iii) $C_6H_5CH_2CONH_2$ ----------

(iv) $CH_3CH(NH_2)COOH$ ----------

(b) Draw the structural formula of each of the following compounds.

(i) 2-methylbutanoic acid ----------

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(ii) Hexan-2-one (2-hexanone) ----------

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4 marks

(iii) 2,4,6-tribromophenol ----------

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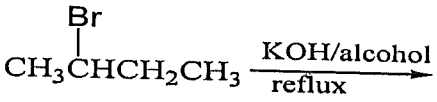
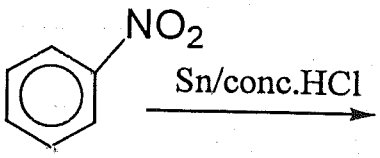
(c) Give the products of following conversions.

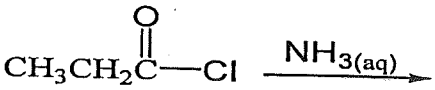
(i)



(ii)



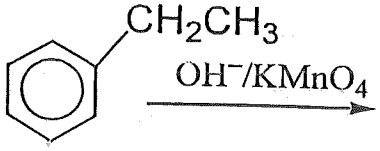
(iii)



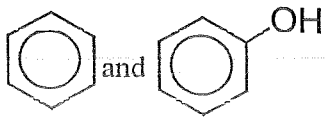
(iv)

$$CH_3CH_2CH(OH)CH_3 \xrightarrow{H^+/K_2Cr_2O_7}$$

(v)



(d) Suggest a chemical test to distinguish between the following pairs of compounds.




(i) ----------

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(ii) $CH_3C \equiv CCH_3$ and $CH_3CH_2C \equiv CH$ ----------

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6 marks

(e) Which compound is more basic: $CH_3NH_2$ or $C_6H_5NH_2$? ----------

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Explain ----------

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2 marks