| Name: | | Class: | |
|---|---|---|---|

# ST ANDREW'S JUNIOR COLLEGE

## JC2 Preliminary Examinations

**Chemistry** **8872/1**

**Higher 1** **18 Sep 2017**

**Paper 1** **1300 − 1350**

Candidates answer on separate paper.

Additional Materials: Writing paper, Data Booklet, OAS

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write you name, civics group and index number on the OAS provided unless this has been done for you.

There are **thirty** questions on this paper. Answer all questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the one you consider correct and record your choice in **soft pencil** on the separate OAS.

**Read the instructions on the OAS very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

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## Section A

For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the one you consider to be correct.

**1** How many carbon atoms are present in 4.0 g of ethanoic acid? [L = Avogradro constant]

**A** L/12

**B** L/15

**C** 2L/15

**D** 2/15L

Mr of ethanoic acid ($CH_3COOH$) = (12.0 x 2) + (1.0 x 4) + (16.0 x 2) = 60.0

Amount of ethanoic acid = 4.0 / 60.0

Amount of carbon present = 2 x 4 / 60 = 2 /15

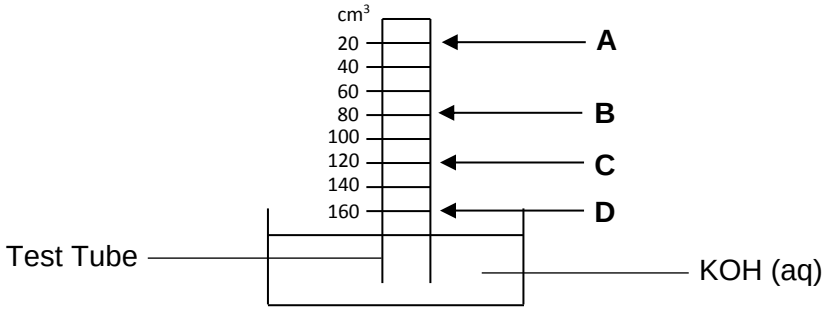
No. of C atoms = (2 / 15) x L = 2L / 15

Ans: (C)

**2** A test tube is filled with 20 $cm^3$ of propane and 160 $cm^3$ of oxygen at room temperature. The open end of the test tube is placed in a beaker of KOH (aq) as shown. The gas mixture was sparked according to the following reaction.

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$$

What will be the final level of liquid in the test tube after it has cooled back to room temperature?




Volume of $O_2$ used = 100 $cm^3$

Volume of $CO_2$ formed = 60 $cm^3$

Volume of $O_2$ remained = 160 - 100 = 60 $cm^3$

Final volume of gas = vol of $CO_2$ + vol of $O_2$ remained = 60 + 60 = 120$cm^3$

Ans: (C)

**3** A sample containing ammonium sulfate ($M_r$ = 132) was warmed with 100 $cm^3$ of 0.500 mol $dm^{-3}$ sodium hydroxide. When the evolution of ammonia ceased, the excess sodium hydroxide solution was neutralised with 25.00 $cm^3$ of 0.500 mol $dm^{-3}$ hydrochloric acid. What was the mass of ammonium sulfate in the sample?

**A** 2.48 g

**B** 4.95 g

**C** 6.60 g

**D** 13.20 g

$(NH_4)_2SO_4 + 2NaOH \rightarrow 2NH_3 + Na_2SO_4 + 2H_2O$

Volume of NaOH reacts with $(NH_4)_2SO_4$ = 100 - 25 = 75.00 $cm^3$

Amount of $(NH_4)_2SO_4$ present = ½ (75 / 1000 x 0.500) = 0.01875 mol

Mass of $(NH_4)_2SO_4$= 0.01875 x 132.1 =2.475 = 2.48 g

Ans: (A)

**4** Which of the following ions has two more electrons in the third quantum shell than in the second quantum shell?

**A** $Ca^{2+}$

**B** $K^+$

**C** $Ti^+$

**D** $V^{2+}$

$_{22}Ti : 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^2\ 4s^2$

$Ti^+ : 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^2\ 4s^1$

Third quantum shell has 10 electrons, second quantum shell has 8 electrons.

Ans: (C)

**5** Which of the following ions would be deflected in an electric field to the same extent as $CO^+$ under the same conditions?

**A** $OF^-$

**B** $Ca^{2+}$

**C** $OH^-$

**D** $BeF^+$

Angle of deflection α charge/mass

$CO^+$ = 1/ (12+16) = 1 / 28

$BeF^+$ = 1 / (9+19) = 1 / 28

Ans: (D)

**6** Which of the following sets of compounds consists of a simple molecular structure, giant ionic structure and giant molecular structure?

**A** $SiO_2$, HBr, $BeCl_2$

**B** $SiCl_4$, $AlF_3$, $C_{(graphite)}$

**C** SrO, $ICl_3$, $SnCl_2$

**D** $C_6H_5CO_2H$, $P_4O_{10}$, $SiO_2$

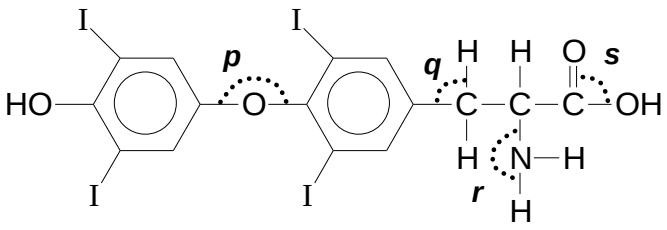
HBr, $BeCl_2$, $ICl_3$, $SiCl_4$, $C_6H_5CO_2H$, $P_4O_{10}$ – simple molecular

$SiO_2$, $C_{(graphite)}$ – giant molecular

SrO, $AlF_3$, $SnCl_2$ – giant ionic

Ans: (B)

**7** The thyroid gland concentrates iodine and uses it to produce thyroxine, which is a hormone that controls the metabolic rate.




Thyroxine

What are the values of the bond angles ***p***, ***q***, ***r*** and ***s***?

| | ***p*** | ***q*** | ***r*** | ***s*** |
|---|---|---|---|---|
| **A** | 180° | 90° | 180° | 90° |
| **B** | 105° | 90° | 107° | 180° |
| **C** | 180° | 90° | 120° | 180° |
| **D** | 105° | 109.5° | 107° | 120° |

p – oxygen has 2 b.p, 2 *l*.p, bond angle = 105°

q – carbon has 4 b.p, no *l*.p, bond angle = 109.5°

r – nitrogen has 3 b.p, 1 *l*.p, bond angle = 107°

s – carbon has 3 b.p, no *l*.p, bond angle = 120°

Ans: (D)

**8** Which of the following reactions can the bond energy of the Si–C*l* bond be determined by using the standard enthalpy change of the reaction?

**A** $SiCl_4$ (*l*) → $SiCl_4$ (g)

**B** $SiCl_4$ (g) → Si (g) + 4C*l* (g)

**C** $SiCl_4$ (g) → $SiCl_2$ (g) + $Cl_2$ (g)

**D** $2Cl_2$ (g) + Si (s) → $SiCl_4$ (g)

ΔH for B = 4 x BE(Si-C*l*)

Ans: (B)

**9** Which of the following shows the sequence of the magnitude of lattice energies of the following compounds in ascending order?

**I** NaC*l*

**II** RbC*l*

**III** MgS

**IV** BaS

**A** I, II, III, IV

**B** II, I, IV, III

**C** III, IV, I, II

**D** IV, III, II, I

$\left|\text{Lattice Energy}\right| \propto \left|\frac{q^+q^-}{r_+ + r_-}\right|$

MgS, BaS has a bigger $q^+q^-$ than NaC*l* and RbC*l*.

$Rb^+$ has a bigger ionic radius than $Na^+$, hence RbC*l* has the smallest magnitude of L.E.

$Mg^{2+}$ has a smaller ionic radius than $Ba^{2+}$, hence MgS has the largest magnitude of L.E.

Ans: (B)

**10** The table below shows the standard enthalpy change of neutralisation, Δ*H*, for the various acids and bases listed.

| **Acid** | **Base** | **Δ*H* / kJ mol$^{-1}$** |
|---|---|---|
| hydrobromic acid | sodium hydroxide | –57.0 |
| **P** | sodium hydroxide | less exothermic than –57.0 |
| hydrofluoric acid | potassium hydroxide | less exothermic than –57.0 |
| **Q** | potassium hydroxide | –57.0 |

What could be **P** and **Q**?

| | P | Q |
|---|---|---|
| **A** | hydrochloric acid | nitric acid |
| **B** | ethanoic acid | hydrofluoric acid |
| **C** | hydrogen cyanide | ethanoic acid |
| **D** | ethanoic acid | hydrobromic acid |

Hydrobromic acid is a strong acid since it reacts with NaOH gives an enthalpy change of –57.0 kJ $mol^{-1}$. Hydrofluoric acid is a weak acid since it reacts with NaOH that gives an enthalpy change that is less exothermic than –57.0 kJ $mol^{-1}$. P must be a weak acid, ethanoic acid and Q must be a strong acid, hydrobromic acid.

Ans: (D)

**11** A chemical plant illegally dumped two radioactive isotopes **P** and **Q** in a landfill. The amount of **P** is 4 times the amount of **Q**. The radioactive decay of isotopes follows first-order kinetics. The half-life of **P** is 2 days whereas that of **Q** is 8 days. By the time the authorities found out about this illegal dumping and analysed a sample of the waste, the ratio of **P** to **Q** was found to be **1**:**2**. How long was the waste in the landfill before the authorities arrived?

**A** 8 days

**B** 16 days

**C** 32 days

**D** 64 days

4P → 2P → 1P → 1/2 P → 1/4 P

= 4 half-lives = 4 x 2 = 8 days

Q → 1/2 Q = 1 half-lives = 1 x 8 = 8 days

Ratio of P : Q = 1/4: 1/2 = 1: 2

Ans : (A)

**12** The table below gives data for the reaction between **A** and **B** at a constant temperature.

| **Experiment** | **[A] / mol $dm^{-3}$** | **[B] / mol $dm^{-3}$** | **Initial rate / mol $dm^{-3}$ $s^{-1}$** |
|---|---|---|---|
| 1 | 0.3 | 0.2 | $4.0 \times 10^{-4}$ |
| 2 | 0.6 | 0.2 | $4.0 \times 10^{-4}$ |
| 3 | 0.6 | 0.8 | $6.4 \times 10^{-3}$ |

Which of the following correctly represents the units of the rate constant, *k,* in the rate equation?

**A** $mol^{-1}\ dm^3\ s^{-1}$

**B** $mol\ dm^{-3}\ s^{-1}$

**C** $mol\ s^{-1}$

**D** $s^{-1}$

Comparing between experiment 1 and 2, when [B] is constant, [A] x 2, rate is the same, therefore it is zero order with respect to [A].

Comparing between experiment 2 and 3, when [A] constant, [B] x 4, rate increases 16 times, therefore it is second order with respect to [B].

Rate = $k\ [B]^2$

$mol\ dm^{-3}\ s^{-1} = k(mol\ dm^{-3})^2$

$k = mol^{-1}\ dm^3\ s^{-1}$

Ans: (A)

**13** At 298 K, 0.20 mol $dm^{-3}$ of propanone reacts with 0.30 mol $dm^{-3}$ of methanol to form 0.04 mol $dm^{-3}$ of acetal as shown below.

$$CH_3COCH_3\ (l) + 2CH_3OH\ (l) \underset{}{\overset{H^+}{\rightleftharpoons}} \underbrace{CH_3C(OCH_3)_2CH_3\ (l)}_{\text{acetal}} + H_2O\ (l)$$

What is the equilibrium constant of the reaction at 298 K?

**A** 0.0385

**B** 0.0455

**C** 0.148

**D** 0.207

| | $CH_3COCH_3\ (l)$ | $CH_3OH\ (l)$ | $CH_3C(OCH_3)_2CH_3\ (l)$ | $H_2O\ (l)$ |
|---|---|---|---|---|
| Initial conc | 0.20 | 0.30 | 0 | 0 |
| Change in conc | 0.20 – 0.04 | 0.30 – 2(0.04) | +0.04 | +0.04 |
| Equilibrium conc | 0.16 | 0.22 | 0.04 | 0.04 |

$K_c = [CH_3C(OCH_3)_2CH_3]\ [H_2O] / [CH_3COCH_3]\ [CH_3OH]^2$

$= (0.04)^2 / [0.16 \times (0.22)^2]$

$= 0.207\ mol^{-1}dm^3$

Ans: (D)

**14** $Fe^{3+}$ and $SCN^-$ react in a closed system to give the complex, $[Fe(SCN)]^{2+}$, which is blood-red in colour.

$Fe^{3+}$ (aq) + $SCN^-$ (aq) ⇌ $[Fe(SCN)]^{2+}$ (aq) $\Delta H < 0$

Which one of the following changes will result in the solution turning pale red?

**A** Increase the concentration of $SCN^-$

**B** Decrease the pressure of the system

**C** Decrease the temperature of the system

**D** Add a small amount of dilute NaOH to the resulting mixture

The NaOH added will react with $Fe^{3+}$ to form $Fe(OH)_3$, causing $[Fe^{3+}]$ to be decreased. By L.C.P, position of equilibrium shift to the left to replenish the $[Fe^{3+}]$, hence the colour becomes less blood-red.

Ans: (D)

**15** A mixture was made by adding 10 $cm^3$ of a solution of pH 1 to 30 $cm^3$ of another solution of pH 5. What is the final pH of the mixture?

**A** 1.6

**B** 2.5

**C** 3.0

**D** 4.0

$[H^+]$ in 10 $cm^3$ = $10^{-1}$ = 0.1

$[H^+]$ in 30 $cm^3$ = $10^{-5}$ = 0.00001

Total amount of $H^+$ = (10/1000 x 0.1) + (30/1000 x 0.00001) = 0.0010003 mol

$[H^+]$ = 0.0010003 / (40/1000)

= 0.0250 mol $dm^{-3}$

pH = $-\log_{10}[H^+] = -\log_{10}(0.0250)$ = 1.6

Ans: (A)

**16** Which of the following is a general trend from left to right of the elements in the third period of the Periodic Table?

**A** The radii of the atoms increase.

**B** The melting points of the chlorides decrease.

**C** The electrical conductivity of the elements decrease.

**D** The first ionisation energies of the elements increase.

Across the period, the effective nuclear charge of the element increases, Hence, more energy is required to remove the valence electrons and ionisation energies increases.

Ans: (D)

**17** Which element has a chloride with a simple molecular structure that is readily hydrolysed in water?

**A** sodium

**B** magnesium

**C** aluminium

**D** silicon

$SiCl_4$ has a simple molecular structure and is completely hydrolysed in water.

**18** Which property decreases from $Na_2O$ to $P_4O_{10}$ for the oxides of period 3 elements?

**A** melting point

**B** covalent character

**C** solubility in aqueous alkali

**D** pH when mixed with water

pH of $Na_2O$ in water = 13; pH of MgO in water = 9; pH of $Al_2O_3$ and $SiO_2$ = 7, $P_4O_{10}$ = 3

Ans: (D)

**19** Linoleic acid is an essential fatty acid with the structural formula.

$CH_3(CH_2)_4CH=CHCH_2CH=CH(CH_2)_7CO_2H$

Which of the following statements about linoleic acid is correct?

**A** It undergoes electrophilic substitution with liquid bromine.

**B** It undergoes oxidation with acidified potassium dichromate(VI) solution.

**C** 1 mole of linoleic acid requires 48 $dm^3$ of hydrogen for hydrogenation at room temperature.

**D** 1 mole of linoleic acid reacts with 1 mole of sodium carbonate to form 24 $dm^3$ of carbon dioxide at room temperature.

1 mole of linoleic acid reacts with 2 mole of $H_2$. 1 mole of gas at r.t.p is 24 $dm^3$. Hence 24 $dm^3$ of $H_2$ is needed.

Ans: (C)

**20** Which property of benzene is reflected as a consequence of the delocalised electrons in its molecule?

**A** Benzene is a planar molecule.

**B** Benzene is a good conductor of electricity.

**C** Substitution in benzene takes place at a carbon atom.

**D** Addition reactions of benzene take place more easily than substitution.

Benzene is resonance stabilised by the delocalised electrons present in its molecule. Hence it will undergo substitution instead of addition reaction.

Ans: (C)

**21** The volatile liquid, fluothane, $CF_3CHBrCl$, is a widely used anaesthetic.

Which statement about fluothane is **incorrect**?

**A** It has a simple molecular structure.

**B** It may cause depletion of ozone layer.

**C** It may undergo substitution with chlorine.

**D** It can form hydrogen bonds between its molecules.

The hydrogen is not bonded to F,O and N hence it is not able to form hydrogen bonds between its molecules.

Ans: (D)

**22** A compound **V** gives yellow precipitate with alkaline aqueous iodine. One mole of **V** liberates one mole of hydrogen when it reacts with excess sodium.

What could be the formula of **V**?

**A** $CH_3CH(OH)CHO$

**B** $CH_3CH(OH)CO_2H$

**C** $HOCH_2CH_2CO_2H$

**D** $HOCH_2CH(CH_3)CH_2OH$

$CH_3CH(OH)$- gives yellow ppt with alkaline aqueous iodine. It has –OH and –COOH group which reacts with 2 moles of sodium to form 1 mole of $H_2$.

Ans: (B)

**23** A compound, **W**, has the following properties.

- It reacts with hydrogen in the presence of nickel catalyst.
- It reacts with phosphorus pentachloride to give off HCl fumes.
- It reacts with sodium hydroxide to form an ionic compound.
- It reacts with ethanol.

What formula could represent **W**?

**A** $CH_3CHO$

**B** $CH_3COCH_3$

**C** $CH_2=CHCO_2H$

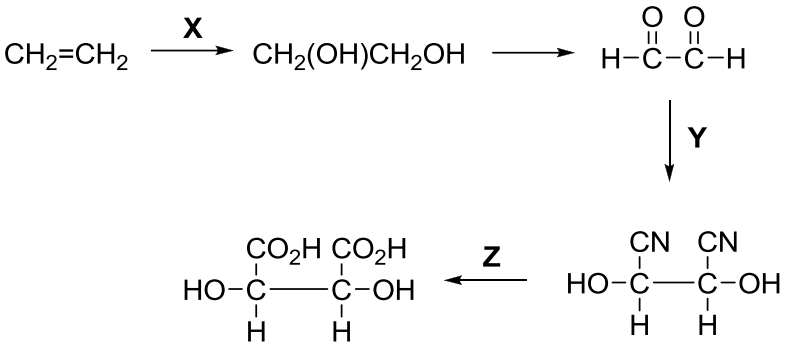
**D** $CH_2=CHCH_2OH$

- Carboxylic acid functional group reacts with NaOH to form $–CO_2^-Na^+$ an ionic compound.
- Carboxylic acid functional group reacts with $PCl_5$ to form RCOCl and HCl.
- Alkene functional group present to reacts with $H_2$ in the presence of Ni catalyst.
- Carboxylic acid functional group reacts with alcohol to form ester.

**X** has both carboxylic acid and alkene functional groups.

Ans: (C)

**24** The following is a method of synthesising tartaric acid, a compound found in wine.




Which set of reagents and conditions can be used for the synthesis?

| | X | Y | Z |
|---|---|---|---|
| **A** | cold concentrated $H_2SO_4$, followed by boiling $H_2O$ | cold HCN, NaOH(aq) | hot $K_2Cr_2O_7$, $H_2SO_4$(aq) |
| **B** | cold $KMnO_4$, $H_2SO_4$(aq) | cold HCN, NaOH(aq) | HCl(aq), heat |
| **C** | cold concentrated $H_2SO_4$, followed by boiling $H_2O$ | ethanolic KCN, heat | hot $K_2Cr_2O_7$, $H_2SO_4$(aq) |
| **D** | cold $KMnO_4$, NaOH(aq) | ethanolic KCN, heat | HCl(aq), heat |

Mild oxidation of **X** with cold $KMnO_4$, $H_2SO_4$(aq) to form diol.

Addition of carbonyl functional group with cold HCN, NaOH(aq) to form cyanohydrin.

Acidic hydrolysis of nitrile group to form carboxylic acid.

Ans: (B)

**25** Which of the following shows the descending order of acid strength?

**A** $CH_3CO_2H$ > $CH_2ClCO_2H$ > $CH_3CH_2OH$

**B** $CH_3CH_2OH$ > $CH_2ClCO_2H$ > $CH_3CO_2H$

**C** $CH_2ClCO_2H$ > $CH_2FCO_2H$ > $CH_3CH_2OH$

**D** $CH_2ClCO_2H$ > $CH_2BrCO_2H$ > $CH_3CO_2H$

F being more electronegative than Cl can better disperse the negative charge on the conjugate base, hence stabilising the conjugate base more, therefore $CH_2FCO_2H$ is the most acidic.

Cl being more electronegative than Br can better disperse the negative charge on the conjugate base, hence stabilising the conjugate base more, therefore $CH_2ClCO_2H$ is more acidic.

$CH_3CO_2H$ is more acidic than $CH_3CH_2OH$ due to the negative charge being able to delocalise over the O-C-O bond in the conjugate base, hence forming a resonance structure.

Acid strength:

$CH_2FCO_2H$ > $CH_2ClCO_2H$ > $CH_2BrCO_2H$ > $CH_3CO_2H$ > $CH_3CH_2OH$

## Section B

For each of the following questions, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

| A | B | C | D |
|---|---|---|---|
| **1**, **2** and **3** are correct | **1** and **2** only are correct | **2** and **3** only are correct | **1** only is correct |

No other combination of statements is used as a correct response.

**26** Materials are insulators when the outer shells of electrons of all the constituent particles are completely filled and there is a considerable energy gap before the next unoccupied shell.

Which compounds have completely filled shells and might therefore act as insulators?

**1** MgO

**2** $SiO_2$

**3** SiC (diamond structure)

MgO has completely filled outer shells as Mg has transferred 2 electrons to oxygen. Ionic compounds in solid states are insulators as there are no free mobile electrons. MgO is sparingly soluble in water, hence no ions are formed.

$SiO_2$ and SiC are giant molecular structure in a tetrahedral network. Therefore the outer shells are completely filled. They are insulators as there are no free mobile electrons.

Ans: (A)

**27** Calcium reacts with water to form calcium hydroxide and hydrogen.

$Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(s) + H_2(g)$

The standard enthalpy change for this reaction can be determined experimentally.

What further information are needed to calculate the standard enthalpy change of formation of calcium hydroxide, $\Delta H_f^{\ominus}$?

**1** $\Delta H_f^{\ominus}$ for $H_2O(l)$

**2** $\Delta H_f^{\ominus}$ for $H_2(g)$

**3** First and second ionisation energies for Ca

$$Ca(s) + 2H_2O(l) \xrightarrow{\Delta H_r^{\ominus}} Ca(OH)_2(s) + H_2(g)$$

$\Delta H_r^{\ominus} = \sum n\Delta H_f^{\ominus}(\text{products}) - \sum n\Delta H_f^{\ominus}(\text{reactants})$

$= [\Delta H_f^{\ominus}(Ca(OH)_2) + \Delta H_f^{\ominus}(H_2)] - [\Delta H_f^{\ominus}(Ca) + 2\Delta H_f^{\ominus}(H_2O)]$

$= [\Delta H_f^{\ominus}(Ca(OH)_2) - 2\Delta H_f^{\ominus}(H_2O)$

$\Delta H_f^{\ominus}(Ca(OH)_2) = \Delta H_r^{\ominus} + 2\Delta H_f^{\ominus}(H_2O)$

Ans: (D)

**28** Which of the following pairs would form an acidic buffer when mixed together?

**1** $CH_3CO_2H$ and NaC*l*

**2** HCN and KCN

**3** $C_6H_5CO_2H$ and $(C_6H_5CO_2)_2Ca$

An acidic buffer is made up of weak acid and its conjugate base. HCN and $C_6H_5CO_2H$ are both weak acid. KCN and $(C_6H_5CO_2)_2Ca$ are the respective conjugate base.

Ans: (C)

**29** A halogenoalkane has the formula of $C_3H_5Cl_3$.

Which of the isomers have the correct IUPAC name?

**1** 1,1,1-trichloropropane

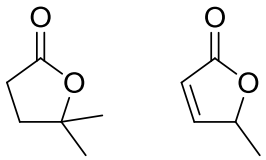
**2** 1,2,2-trichloropropane

**3** 2,2,3-trichloropropane

2,2,3- trichloropropane is the same as 1,2,2-trichloropropane. Smaller numbers are preferred on the IUPAC name.

Ans: (B)

**30** Below are the structures of compounds **X** and **Y**.



**X** **Y**

Which sets of reagents and conditions can be used to distinguish between them?

**1** aqueous bromine

**2** acidified $K_2Cr_2O_7$, heat

**3** alkaline aqueous iodine, heat

For **1**, C=C in **Y** will decolourise orange-red $Br_2$(aq). No decolouisation of $Br_2$(aq) for **X**.

For **2**, ester group in **X** undergoes acid hydrolysis to form tertiary alcohol which cannot be oxidised by $K_2Cr_2O_7$. There is no change in the colour of solution. However, the acid hydrolysis of **Y** formed secondary alcohol which can be oxidised by $K_2Cr_2O_7$. The colour of solution changes from orange to green.

For **3**, both the ester groups in **X** and **Y** undergo base hydrolysis. However, only **Y** shows a positive iodoform test due to presence of $CH_3CH(OH)$– group after hydrolysis.

Ans: (A)

**--- End of Paper ---**