Chemistry Olympiad Sri Lanka

Preliminary Selection Test – 2019

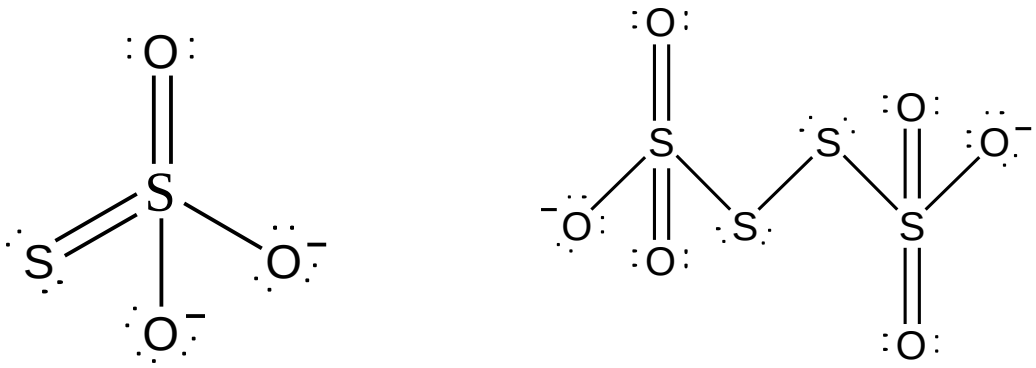
Marking Scheme

Section B: Structured Questions

Question 1

I.

(a)



1x2 = 02 marks

(b)

IO_3^- and I^-

$$2I^- \longrightarrow I_2 + 2e$$ **01 mark**

$$10e + 12H^+ + 2IO_3^- \longrightarrow I_2 + 6H_2O$$ **01 mark**

$$12H^+ + 2IO_3^- + 10I^- \longrightarrow 6I_2 + 6H_2O$$ **01 mark**

$$6H^+ + IO_3^- + 5I^- \longrightarrow 3I_2 + 3H_2O$$

I_2 and $S_2O_3^{2-}$

$$I_2 + 2Na_2S_2O_3 \longrightarrow 2I^- + 2Na^+ + Na_2S_4O_6$$

or

$$I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_4O_6$$

01 mark

(c)

$$S_2O_3^{2-} + H^+ \longrightarrow S + HSO_3^-$$

02 marks

(d) Average titrant volume = 20.00 cm^3

$$[Na_2S_2O_3] = \left(\frac{0.05}{1000} \times 20.00 \times 2 \times \frac{1}{20.00}\right) mol\ dm^{-3} = 0.10\ mol\ dm^{-3}$$

01 mark

(e)

$$[Acid] = \left(\frac{0.10}{1000} \times 11.20 \times \frac{1}{2} \times \frac{6}{3} \times \frac{1000}{20.00}\right) mol\ dm^{-3} = 0.056\ mol\ dm^{-3}$$

03 marks

(f)

$$CaCl_2 + C_2H_2O_4 \longrightarrow 2HCl + CaC_2O_4$$

02 marks

(g)

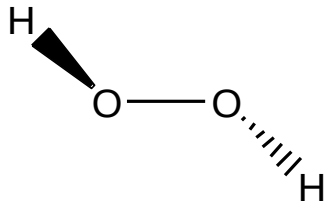
$$[H^+] = 0.01\ mol\ dm^{-3}$$

$$Minimum\ CaCl_2\ amount = \left(\frac{0.01}{1000} \times 100.00 \times \frac{1}{2}\right) mol \times 111\ g\ mol^{-1} = 0.056\ g$$

02 marks

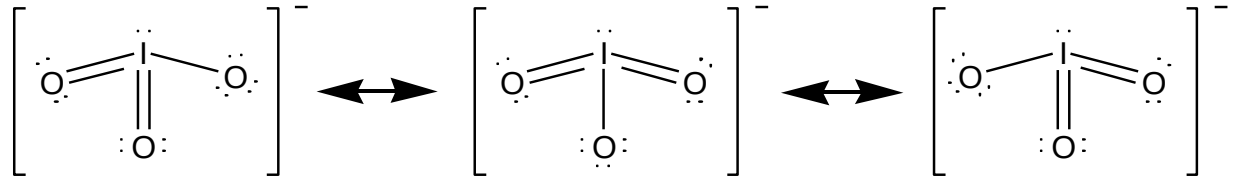
II.

(a)



Two hydrogens are not on the same plane. **01 mark**

(b)



02 marks

(c)

(i)

$$12H^+ + 2IO_3^- + 10e \longrightarrow I_2 + 6H_2O$$ **0.5 marks**

$$H_2O_2 \longrightarrow O_2 + 2H^+ + 2e$$ **0.5 marks**

$$12H^+ + 2IO_3^- + 5H_2O_2 \longrightarrow I_2 + 6H_2O + 5O_2 + 10H^+$$

$$2H^+ + 2IO_3^- + 5H_2O_2 \longrightarrow I_2 + 6H_2O + 5O_2$$ **01 mark**

(ii)

$$I_2 + 6H_2O \longrightarrow 2IO_3^- + 12H^+ + 10e$$ **0.5 marks**

$$2H^+ + H_2O_2 + 2e \longrightarrow 2H_2O$$ **0.5 marks**

$$I_2 + 6H_2O + 10H^+ + 5H_2O_2 \longrightarrow 2IO_3^- + 12H^+ + 10H_2O$$

$$I_2 + 5H_2O_2 \longrightarrow 2IO_3^- + 2H^+ + 4H_2O$$ **01 mark**

(d) I_3O and IO_2H_2 should be circled. **01 mark**

Oxidation number of iodine: IOH = +1 IO_2H = +3 I_2O_3 = +3 I_2O = +1 IO_3H = +5

Offer 01 mark if 4 out of 5 are correct.

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Question 2

I.

(a)

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

And

$$C_4H_{10} + \frac{13}{2}O_2 \rightarrow 4CO_2 + 5H_2O$$

Offer 01 mark if both are correct.

$$CO_2 + 2NaOH \rightarrow Na_2CO_3 + H_2O$$

And

$$CO_2 + NaOH \rightarrow NaHCO_3$$

Or

$$2CO_2 + 3NaOH \rightarrow Na_2CO_3 + NaHCO_3 + H_2O$$

Offer 01 mark if both are correct. (01 mark can be offered if the last reaction is written instead of both.)

(b)

$$Total\ amount\ of\ CO_2 = 9.54\ g \times 106\ g\ mol^{-1} + 8.40\ g \times 84\ g\ mol^{-1} = 0.19\ mol$$

01 mark

$$Total\ volume\ of\ CO_2 = 0.19\ mol \times 22.4\ dm^3\ mol^{-1} = 4.25\ dm^3$$

01 mark

(c)

$$Total\ amount\ of\ C_3H_8 + C_4H_{10} = 1.12\ dm^3 \times 22.4\ dm^3\ \ mol^{-1} = 0.05\ mol$$

If the amount of C_3H_8 is *x*, considering total amount of CO_2,

$$3x + 4(0.05 - x) = 0.19$$

$$x = 0.01\ mol$$

01 mark

$$Mass\ fraction\ of\ C_3H_8 = \frac{(0.01 \times 44.1)\ g}{(0.01 \times 44.1)\ g + (0.04 \times 58.12)\ g} = 0.16$$

02 marks

II.

(a)

$$Total\ heat\ energy = \frac{13 \times 10^3\ g}{44.1\ g\ mol^{-1}} \times (-2220\ kJ\ mol^{-1}) = 6.48 \times 10^5\ kJ$$

01 mark

(b)

$$Total\ CO_2 = \frac{13 \times 10^3\ g}{44.1\ g\ mol^{-1}} \times 3 \times 44.1\ g\ mol^{-1}$$

$$Total\ CO_2 = 39\ kg$$ **01 mark**

$$CO_2\ released\ to\ generate\ 1\ kJ\ of\ heat = \frac{39\ kg}{6.48 \times 10^5\ kJ} = 6.01 \times 10^{-5}\ kg\ kJ^{-1}$$

01 mark

(c)

$$Total\ heat\ energy = \frac{13 \times 10^3\ g}{58\ g\ mol^{-1}} \times (-2877\ kJ\ mol^{-1}) = 6.44 \times 10^5\ kJ$$

01 mark

$$Total\ CO_2 = \frac{13 \times 10^3\ g}{58\ g\ mol^{-1}} \times 4 \times 44.1\ g\ mol^{-1}$$

$$Total\ CO_2 = 39.4\ kg$$

$$CO_2\ released\ to\ generate\ 1\ kJ\ of\ heat = \frac{39.4\ kg}{6.44 \times 10^5\ kJ} = 6.12 \times 10^{-5}\ kg\ kJ^{-1}$$

01 mark

(d) C_3H_8 has to be circled.

01 mark

(e)

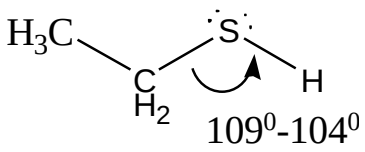
$$\frac{15\ kJ\ s^{-1} \times 22.4\ \times 1000\ cm^3\ mol^{-1}}{2220\ kJ\ mol^{-1}} = 151.4\ cm^3\ s^{-1}$$ **02 marks**

(f)

$$\frac{9.52\ atm}{140\ PSI} \times \frac{1.013 \times 10^5\ N\ m^{-2}}{1\ atm} \approx \frac{6888\ N\ m^{-2}}{1\ PSI}$$ **01 mark**

III.

(a)



02 marks

(b)

$$\frac{13000\ g}{44.1\ g\ mol^{-1}} \times \frac{0.02}{10^6} \times 58\ g\ mol^{-1} = 3.42 \times 10^{-4}\ g$$ **02 marks**

(c) Ethanol > Ethyl Mercaptan > Butane > Propane **01 mark**

IV.

(a) a = $mol^{-1}\ m^3$ b = $N\ m^4\ mol^{-2}$ **or** $Pa\ m^6\ mol^{-2}$

1.5 marks

(b)

$$P = \frac{RT}{(V_m - b)} - \frac{a}{V_m^2}$$

1.5 marks

(c)

$$(V_m - b)V_m^2 P = RTV_m^2 - (V_m - b)a$$

$$(V_m - b)V_m^2 = \frac{RT}{P}V_m^2 - \frac{a}{P}V_m + \frac{ab}{P}$$

$$V_m^3 - bV_m^2 - \frac{RT}{P}V_m^2 + \frac{a}{P}V_m - \frac{ab}{P} = 0$$

$$V_m^3 - \left(b + \frac{RT}{P}\right)V_m^2 + \frac{a}{P}V_m - \frac{ab}{P} = 0$$

02 marks

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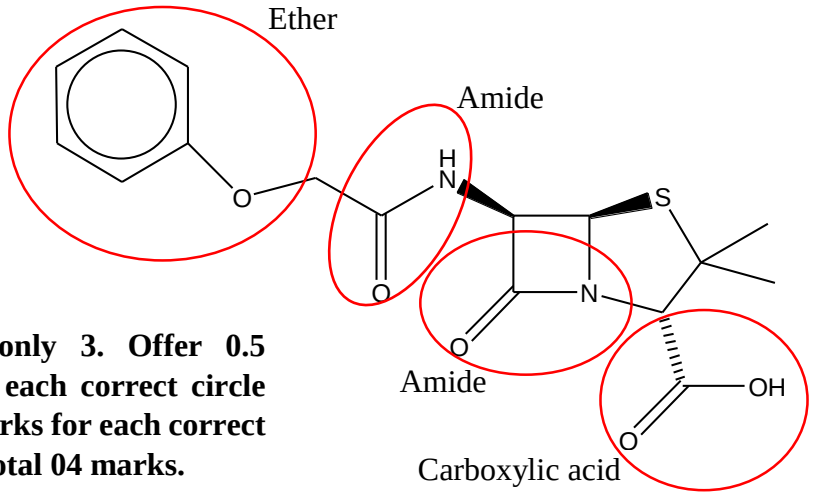
Question 3

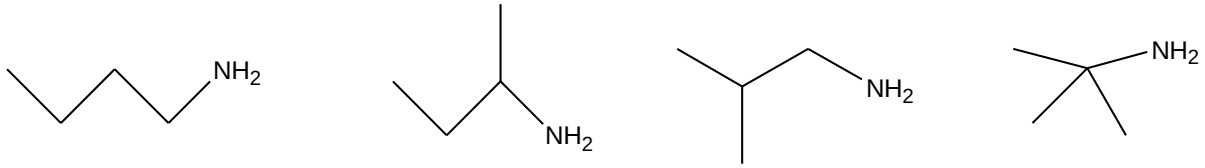
I.



Consider only 3. Offer 0.5 marks for each correct circle and 0.5 marks for each correct naming. Total 04 marks.

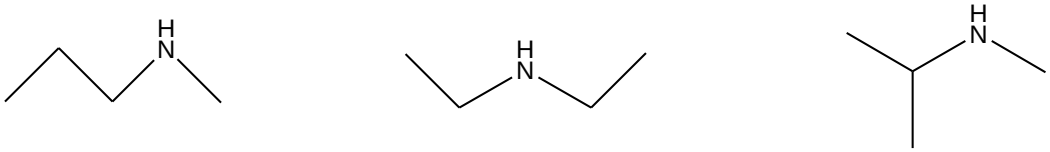
II.

(a)



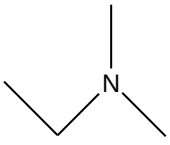
0.5x4 = 02 marks

(b)



1x3 = 03 marks

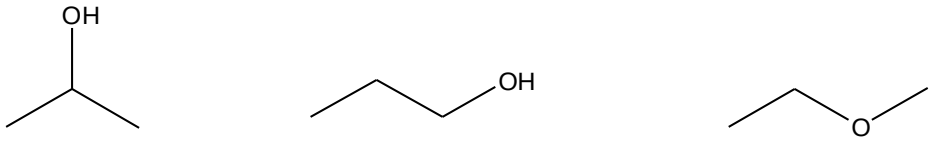
(c)



03 marks

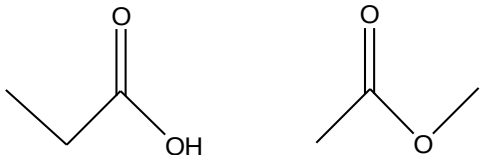
III.

(a)



03 marks

(b)



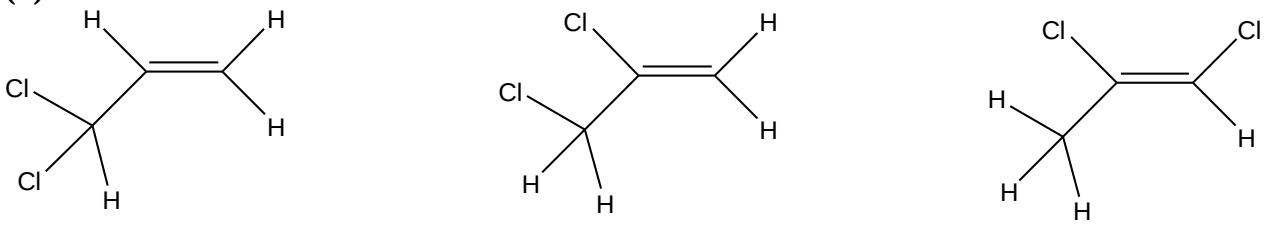
02 marks

IV.

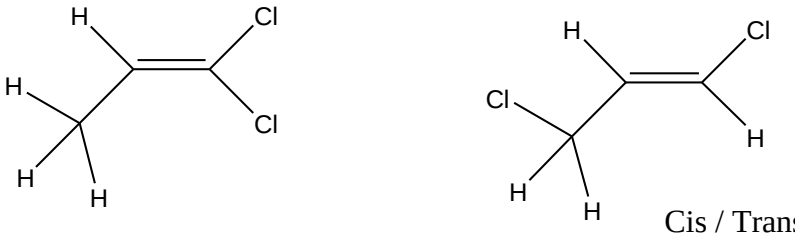
(i) (8-6)/2 = 1

Calculation: 01 mark **Answer: 01 mark**

(ii)



Cis / Trans



Cis / Trans

Any two structures: 02 marks

V.

(a) El **(b)** Nu **(c)** N **(d)** Nu

0.5x4 = 02 marks

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