

IJSO 2021 Chemistry Theory solution set

Solution: Q.1.1

2M

Since the reaction is of first order with respect to sucrose,

Rate constant $k = (2.303/t) \cdot \log a/a-x$

$$k_{303K} = \frac{2.303 \log \{12.5 - (-15.5)\}}{600 \{(-3.0) - (-15.5)\}}$$

$$= \frac{2.303 \log 28.0}{600 \cdot 12.5} = 1.344 \times 10^{-3} \text{ s}^{-1} \quad (0.5 \text{ M})$$

$$k_{311K} = \frac{2.303 \log \{12.5 - (-15.5)\}}{600 \{(-8.0) - (-15.5)\}}$$

$$= \frac{2.303 \log 28.0}{600 \cdot 7.5} = 2.187 \times 10^{-3} \text{ s}^{-1} \quad (0.5 \text{ M})$$

$$\text{Arrhenius eqn: } \log \frac{k_{311}}{k_{303}} = \frac{E}{2.303 R} \left\{ \frac{1}{T_1} - \frac{1}{T_2} \right\}$$

$$\log \frac{2.187 \times 10^{-3}}{1.344 \times 10^{-3}} = \frac{E}{2.303 \times 8.314} \left\{ \frac{1}{311} - \frac{1}{303} \right\}$$

$$\log 1.627 = \frac{E}{2.303 \times 8.314} \left\{ \frac{1}{311} - \frac{1}{303} \right\}$$

$$E = 47.66 \text{ kJ mol}^{-1} \quad (1.0 \text{ M})$$

Deduct 0.25 Marks, if correct units are not written.

Solution:1.2

1M

Arrhenius equation $\log k = \log A - E/2.303 RT$

$$T = 27 + 273 = 300 \text{ K}$$

$$R = 8.314 \times 10^{-3} \text{ kJ K}^{-1} \text{ mol}^{-1}$$

$$\text{When } E = 60 \text{ kJ mol}^{-1}, \log k_2 = \log A - 60/2.303 (8.314 \times 10^{-3}) 300$$

$$\text{When } E = 66 \text{ kJ mol}^{-1}, \log k_1 = \log A - 66/2.303(8.314 \times 10^{-3}) 300$$

Subtracting we get,

$$\log k_2 - \log k_1 = [-60 - (-66)]/2.303(8.314 \times 10^{-3}) 300$$

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$$= 6/2.303 (8.3 \times 10^{-3}) 300$$

$$= 1.0463$$

$$\log k_2/k_1 = 1.0677 \quad (0.75M)$$

$$\text{Therefore } k_2/k_1 = 11.66 \quad (0.25M)$$

Solution:

1.3

2Marks

(A) : CuCO_3 (B) : CuS (C) : $\text{Cu}(\text{NO}_3)_2$ D: $\text{Cu}(\text{OH})_2$ **(0.25 marks for each correct identification)**

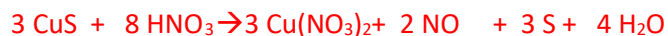
Reactions:



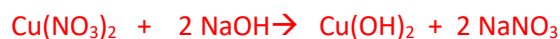
A



B



C



D

(0.25 marks for each correctly balanced reaction)

Soluion Q.2

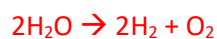
2.1) 1 lit/min for 15 mins 4 times = 60 lit

21% of oxygen = 100 % air

60 lit of oxygen = $(60/21) \times 100 = 286 \text{ lit}$ **(0.5M)**

(Deduct 0.25 marks if correct unit is not written)

2.2) For getting 60 lit of oxygen



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22.4 lit of oxygen = 1 mol O₂ = 2 mol water = 36 g = 36 mL of water

60 lit of oxygen = (60 x 36)/22.4 = **96.43 mL of water** (0.5M)

(Deduct 0.25 marks if correct unit is not written)

2.3) $P_1V_1 = P_2V_2$

Available oxygen: 340 L, 13700 kPa

Required at 101.3 kPa

$V_2 = (340 \times 13700) / 101.3 = \mathbf{45982 \text{ L}}$ (0.25 M)

Required rate: 5 L/min

Hence 45982 L available for 9196 min

$$= 9196/60 = 153 \text{ hrs} = 6.38 \text{ days}$$

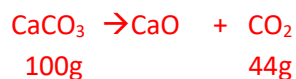
Fresh supply needed after 6 days (0.25 M)

2.4) **1.5M**

$PV = nRT$ or $n = PV/RT = 1 \times 2840 / (0.0821 \times 303)$

$n = \mathbf{114 \text{ mol}}$ (0.25M)

$n = 114 \text{ mole CO}_2 = 114 \times 44 \text{ g CO}_2$



Required $114 \times 44 = \mathbf{5016 \text{ g CO}_2}$ (0.5M)

(Deduct 0.25 marks if correct unit is not written)

$100 \times 5016 / 44 \text{ g CaCO}_3$

But limestone contains 80% CaCO₃

100 g limestone = 80 g CaCO₃

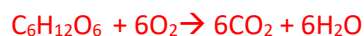
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$$\begin{aligned} \text{Hence limestone reqd} &= (100 \times 100 \times 5016) / (44 \times 80) \\ &= 14250\text{g} = \mathbf{14.25\text{ kg}} \quad \quad \quad \mathbf{(0.25M)} \end{aligned}$$

$$\begin{aligned} \text{KE} &= (3/2) n R T = (3/2) \times 114 \times 8.314 \times 303 \text{ joules} \\ &= 4.31 \times 10^5 \text{ joules} = \mathbf{431\text{kJ}} \quad \quad \quad \mathbf{(0.5M)} \end{aligned}$$

(Deduct 0.25 marks if correct unit is not written)

2.5) 1M



6 moles O_2 reqd per mole of glucose

6 X 22.4 lit of oxygen at STP is required for 1 mole of glucose = 134.4 lit of oxygen at STP **(0.25M)**

$$P_1 V_1 / T_1 = P_2 V_2 / T_2$$

$$V_2 = (1 \times 134.4 \times 303) / 273 = \mathbf{149.17\text{ L}} \text{ at } 30^\circ\text{C} \quad \quad \quad \mathbf{(0.5M)}$$

6 moles of oxygen = **192 g** **(0.25 M)**

2.6) 1M

Let the volume of the gases be a.

rate of diffusion of oxygen = $a/3600$

$$\frac{\text{time taken for CO}_2}{3600} = \sqrt{(44/32)} = \sqrt{1.375} = 1.173$$

$$\text{Time taken for CO}_2 = 3600 \times 1.173 = \mathbf{4223\text{ s}} \quad \quad \quad \mathbf{(0.5)}$$

(Deduct 0.25 marks if correct unit is not written)

$$\text{Similarly, time taken for Cl}_2 = 3600 \sqrt{(71/32)} = 3600 \times 1.489 = \mathbf{5360.4\text{ s}} \quad \quad \quad \mathbf{(0.5M)}$$