CHEM1612 Worksheet 3 – Answers to Critical Thinking Questions

The worksheets are available in the tutorials and form an integral part of the learning outcomes and experience for this unit.

Model 1: Enthalpy ($\Delta_{\text{rxn}}H$) and Entropy ($\Delta_{\text{rxn}}S$) of Reaction

1. $\Delta_{\text{rxn}}H^\circ = -57 \text{ kJ mol}^{-1}$. $\Delta_{\text{rxn}}S^\circ = -176 \text{ J K}^{-1} \text{ mol}^{-1}$
2. The reaction involves making a N-N bond, with no bonds being broken. It is exothermic. The reaction involves the conversion of 2 mol of gas $\rightarrow$ 1 mol of gas. The entropy decreases.
3. $\Delta_{\text{rxn}}H^\circ = -28.5 \text{ kJ mol}^{-1}$. $\Delta_{\text{rxn}}S^\circ = -88 \text{ J K}^{-1} \text{ mol}^{-1}$. These values are exactly half those for reaction A.
4. $\Delta_{\text{rxn}}H^\circ = +57 \text{ kJ mol}^{-1}$. $\Delta_{\text{rxn}}S^\circ = +176 \text{ J K}^{-1} \text{ mol}^{-1}$. These values are equal to -1 times the values for reaction A. Reaction C involves breaking a N-N bond, with no bonds being made. It is endothermic. The reaction involves the conversion of 1 mol of gas $\rightarrow$ 2 mol of gas. The entropy increases.

Model 2: Free Energy of Reaction ($\Delta_{\text{rxn}}G$)

1. Favourable.
2. Unfavourable.
3. Unfavourable.
4. Favourable.
5. The temperature.
6. (a) $\Delta_{\text{rxn}}G^\circ = -4550 \text{ J mol}^{-1} = -4.55 \text{ kJ mol}^{-1} = -5 \text{ kJ mol}^{-1}$ (1 sf). Reaction is favourable.
   (b) $\Delta_{\text{rxn}}G^\circ = +13050 \text{ J mol}^{-1} = +13.05 \text{ kJ mol}^{-1} = +13 \text{ kJ mol}^{-1}$ (1 sf). Reaction is unfavourable.
7. (a) $\Delta_{\text{rxn}}G^\circ = +4550 \text{ J mol}^{-1} = +4.55 \text{ kJ mol}^{-1} = +5 \text{ kJ mol}^{-1}$ (1 sf). Reaction is unfavourable.
   (b) $\Delta_{\text{rxn}}G^\circ = -13050 \text{ J mol}^{-1} = -13.05 \text{ kJ mol}^{-1} = -13 \text{ kJ mol}^{-1}$ (1 sf). Reaction is favourable.
8. An exothermic reaction becomes less favourable as the temperature is increased.
9. An endothermic reaction becomes more favourable as the temperature is increased.
10. $\Delta_{\text{rxn}}H > 0$ and $\Delta_{\text{rxn}}S < 0$.

Model 3: The Gas Laws

1. (i) Boyle’s Law: $V \propto n$ \hspace{1cm} (ii) Charles’ Law: $V \propto T$ \hspace{1cm} (iii) Avogadro’s Hypothesis: $V \propto P$

2. As 1.000 atm = 1.01325 $\times$ $10^5$ Pa and 22.414 L = 0.022414 m$^3$,

$$R = \frac{PV}{nT} = \frac{(1.01325 \times 10^5 \text{ Pa}) \times (0.022414 \text{ m}^3)}{(1.000 \text{ mol}) \times (273.15 \text{ K})} = 8.314 \text{ Pa m}^3 \text{ mol}^{-1} \text{ K}^{-1}$$
3  (a) \(22.414 \text{ L corresponds to } 0.022414 \text{ m}^3\).

(b) \[
R = \frac{PV}{nT} = \frac{(1.01325 \times 10^5 \text{ Pa}) \times (0.022414 \text{ m}^3)}{(1.000 \text{ mol}) \times (273.15 \text{ K})} = 8.314 \text{ Pa m}^3 \text{ mol}^{-1} \text{ K}^{-1}
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The units arise directly from the equation: \((\text{Pa} \times \text{m}^3) / (\text{mol} \times \text{K})\).

**Model 4: Partial Pressures**

1. \(P_{N_2} = 0.80 \times 1.0000 \text{ atm} = 0.80 \text{ atm} \)
   \(P_{O_2} = 0.20 \times 1.0000 \text{ atm} = 0.20 \text{ atm} \)
   \(P_{\text{total}} = (0.20 + 0.80) \text{ atm} = 1.00 \text{ atm}\)

2. At 15.0 m, \(P = 2.50 \text{ atm} \). \(V_{15.0 \text{ m}} = 2.40 \text{ L}\).

3. At 30.0 m, \(P = 4.00 \text{ atm} \). \(V_{\text{surface}} = 20. \text{ L}\). It will burst.

4. Air caught in a cavity will try to expand as the pressure is reduced during ascent. If trapped, it may cause severe pain or a perforated eardrum in the ear or very severe toothache in a tooth.

5. \(P_{35 \degree \text{C}} = 209 \text{ atm}\).

6. The increasing pressure leads to an increase in the density, \(\rho = \frac{MP}{RT}\). More air is held in the same volume so the density increases.

7. From Q1, \(P_{O_2} = 0.20 \text{ atm at the surface} \). At a depth of 10.0 m, \(P_{\text{total}} = 2.0 \text{ atm} \) and so \(P_{O_2} = 0.40 \text{ atm} \). The increase in total pressure does not affect the percentage composition of the air.

8. If \(P_{O_2} = 1.6 \text{ atm} \) then \(P_{\text{total}} = 8.0 \text{ atm} \). This corresponds to a depth of 70.0 m.

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**Key to success:** practice further by completing this week’s tutorial homework

**Key to even greater success:** practice even further by completing this week’s suggested exam questions