CHEM1109 (Life Sciences Course) - November 2009

2009-N-2

- Assume 1 mol of reactants at initial temperature of 25 °C. Need to show that ΔH for the reaction is greater than the amount of energy required to melt 2 mol of Fe + heat all the products (2 mol of Fe + 1 mol of Al_2O_3) to the m.p. of Fe.

  $\Delta H = \sum\Delta_f H(\text{products}) - \sum\Delta_f H(\text{reactants})$

  $= \Delta_f H(Al_2O_3) + 2\Delta_f H(Fe) - (2\Delta_f H(Al) + \Delta_f H(Fe_2O_3))$

  $= -1676 + 2 \times 0 - (2 \times 0 - 824)$

  $= -852 \text{ kJ mol}^{-1}$

  ΔH to heat 2 mol of Fe to its m.p.

  $\Delta H = 25 \text{ J K}^{-1} \text{ mol}^{-1} \times (1535-25) \text{ K} \times 2 \text{ mol} = 75.5 \text{ kJ}$

  ΔH to heat 1 mol of Al_2O_3 to m.p. of Fe

  $\Delta H = 79 \text{ J K}^{-1} \text{ mol}^{-1} \times (1535-25) \text{ K} \times 1 \text{ mol} = 119 \text{ kJ}$

  ΔH to melt 2 mol of Fe

  $\Delta H = 14 \text{ kJ mol}^{-1} \times 2 \text{ mol} = 28 \text{ kJ}$

  Total energy required to melt the iron = 75.5 + 119 + 28 = +222.5 kJ

2009-N-3

- Heat: energy contained in kinetic energies of molecules that flows from hotter to cooler temperatures.

  $P\Delta V$ work: work done by or on a system by a change in volume against a constant pressure.

  Internal energy: the total energy contained within a system; the difference in internal energy in a system is the sum of the heat and work done by or on the system.

  Enthalpy change: the difference in enthalpy between an initial and final state, the enthalpy being the heat of a system at constant pressure.

  Entropy: a measure of the distribution of heat, related to the number of ways or the probability of its distribution, hence to the level of disorder.

  Equilibrium constant: the ratio of the concentrations (or partial pressures) of reactants over products, each raised to its stoichiometric coefficient, when the system is at equilibrium.

  Reaction quotient: the value of the equilibrium constant expression under any conditions, not at equilibrium.

  Triple point: The temperature and pressure at which a substance can exist as a solid, liquid and gas in equilibrium.

2009-N-4

- 6.6 g

  3.6 L

2009-N-5

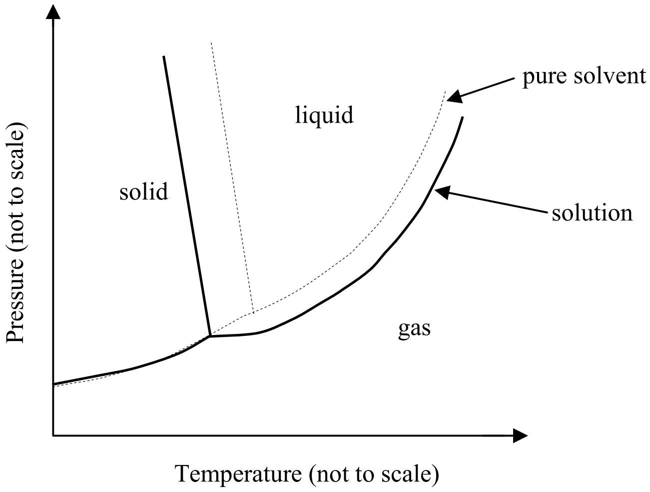
- 4.33
- 6.0×10^3 J mol^{-1}

  2.8×10^{-4}

  In the forward direction (as $Q < K$)

2009-N-6

- The presence of solute particles lowers the vapour pressure of the solution compared to that of the pure solvent. This results in a lowering of the freezing point as shown in the phase diagram.



103 g

2009-N-7

0.025 M

3.15 2.38

7.60

Initial pH is unchanged.
The pH at half-equivalence point will be the same.
The pH at equivalence point will be lower.

2009-N-8

- 6

2009-N-9

- 0.35 g
- 5.1×10^{-22}

2009-N-10

- ΔG is the change in free energy due the completion of a redox reaction.

  n is the number of electrons exchanged.

  E_{cell} is the cell potential as defined in the Nernst equation:.

  $$E = E^\circ - (RT/nF) \times \ln Q$$

2009-N-11

- Collision theory states that molecules must collide to react, and orientation, collision frequency and energy factors determine the reaction rate. Not all collisions are effective - molecules need to be orientated correctly and they need to have enough energy (above the activation energy, E_a) for a reaction to occur. Increasing the temperature increases the number of collisions that exceed E_a. Collision theory is summarised in the Arrhenius law, $k = Ae^{-Ea/RT}$ where A is the "frequency factor", or pre-exponential factor – related to collision frequency and orientation of colliding molecules. Arrhenius law shows that the higher T, the larger the rate constant k, and the higher is the reaction rate.
- As a tracer, the element should ideally have a short half-life, of around a few hours, long enough for it to be produced, administered and imaged, but short enough for it to decay quickly so that it stops being radioactive in the body of the patient.

  A longer half-life would be more suited for a topical treatment of cancer, to impose radiation to the affected area with a higher activity for a longer time.
- Colloidal suspensions can be stabilised either electrostatically or sterically. Electrostatic repulsions between particles with the same charge can stabilise a suspension. The presence of an adsorbed polymer layer on the particles, can also stabilise the suspension because an entropic repulsion sets in between the polymer layers.

  A suspension stabilised electrostatically can be destabilised by adding an electrolyte (e.g. NaCl), which decreases the repulsion between particles, causing the suspension to aggregate and precipitate. Heating or stirring vigorously can also destabilise a suspension by increasing the number of collisions between particles.

2009-N-12

- Rate = $k[\mathrm{I}]^2[\mathrm{Ar}]$

  $k = 8.70 \times 10^9$ L^2 mol^{-2} s^{-1}

  44 mol L^{-1} s^{-1}

2009-N-13

- 1.63×10^{-6}
- $[\mathrm{Ag^+(aq)}] = 3.2 \times 10^{-9}$ M $[\mathrm{Cl^-(aq)}] = 0.056$ M $[\mathrm{Na^+(aq)}] = 0.086$ M

2009-N-14

- $\mathrm{Fe(s) + 2H^+(aq) \rightarrow Fe^{2+}(aq) + H_2(g)}$

  $\mathrm{Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)}$

  $\mathrm{Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)}$

  Cu does not react as the oxidation potential for Cu is negative.
  Sn would be expected to react as it has a slightly positive oxidation potential. The fact that it doesn't is due to a high overpotential for the formation of H_2 gas. All the other metals react, evolving H_2(g) as expected. The higher the oxidation potential (Mg > Zn > Fe), the more vigorous the reaction.

  Fe, when placed in contact with another metal with a higher oxidation potential (e.g. Zn, Mg) will act as the cathode. The other metal will act as the sacrificial anode and will be oxidised preferentially.