Answer on Question #64158 - Chemistry - General Chemistry

1. If 5.40 kcal of heat is added to 1.00 kg of water at 100°C, how much steam at 100°C is produced? Show all calculations leading to an answer.

   Answer
   Since the temperatures of water and steam in the task are both equal to 100°C, all heat is used for changing the state (vaporization). The specific latent heat of water vaporization L = 540 kcal/kg. That means that 1 kg of water requires 540 kcal of heat to boil, L = Q/m. Thus, m = Q/L and 5.40 kcal of heat (Q) produces m = 5.40 kcal / 540 kcal/kg = 0.01 kg of steam.

2. The Kw of water varies with temperature. Calculate the pH of water at 46°C with a Kw = 1.219 x 10-14. Show all calculations leading to an answer.

   Answer
   $H_2O \leftrightarrow H^+ + OH^-$
   Kw is a water autoionization constant, $Kw = [H^+]\cdot[OH^-]$,
   where $[H^+]$ is the molar concentration of hydrogen (or hydroxonium ion), and $[OH^-]$ is the concentration of hydroxide ion. At pure water, as it can be sees from the chemical equation above, H^+ and OH^- molar concentrations are equal, $[H^+] = [OH^-]$.
   So, $Kw = [H^+]^2$
   Thus, $[\mathrm{H^+}] = \sqrt{\mathrm{K_w}}$
   By definition, $pH = -\log_{10}[H^+]$
   So, $\mathrm{pH} = -\log_{10}\sqrt{\mathrm{K_w}}$
   At 46°C $\mathrm{pH} = -\log_{10}\sqrt{1.219 \times 10^{-14}} = 6.957$

3. Calculate the hydroxide ion concentration of a solution with pH = 3.25. Show all calculations leading to an answer.

   Answer
   By definition, $pH = -\log_{10}[H^+]$. Thus, hydrogen concentration $[H^+] = 10^{-pH} = 10^{-3.25}$
   Water autoionization constant $Kw = [H^+]\cdot[OH^-] = 1.00 \times 10^{-14}$
   So, $[OH^-] = Kw / [H^+] = 1.00 \times 10^{-14} / 10^{-3.25} = 1.78 \times 10^{-11}$

4. The following unbalanced equation describes the reaction that can occur when lead (II) sulfide reacts with oxygen gas to produce lead (II) oxide and sulfur dioxide gas:
   PbS + O2 ? PbO + SO2
   Balance the equation and describe in words the electron transfer(s) that takes place.

   Answer
   $2PbS + 3O_2 \rightarrow 2PbO + 2SO_2$
   O has an oxidation number of zero in O_2, but O in compounds has an oxidation number of -2, so each atom of O gets 2 electrons during the reaction. The oxidation number of Pb remains the same (+2). S in compound PbS has an oxidation number of -2, but in compound

SO_2 it has an oxidation number of +4, so each atom of S loses 6 electrons during the reaction.

5. What type of radiation is emitted when chromium-51 decays into manganese-51? Show the nuclear equation that leads you to this answer.

Answer

Using the in periodic table it can be found that we deal with ${}^{51}_{24}\mathrm{Cr}$ and ${}^{51}_{25}\mathrm{Mn}$. These isotopes have the same mass number, but different atomic numbers. During the decay, ${}^{51}_{24}\mathrm{Cr}$ changes atomic number by 1, because 1 neutron converts into 1 proton and 1 electron.

${}^{51}_{24}\mathrm{Cr} \rightarrow {}^{51}_{25}\mathrm{Mn} + {}^{0}_{-1}e$

Electron is emitted in the reaction. Such type of decay is called beta-minus decay.

6. A radioactive nucleus alpha decays to yield a sodium-24 nucleus in 14.8 hours. What was the identity of the original nucleus? Show the nuclear equation that leads you to this answer.

Answer

Products of decay are following:

${}^{24}_{11}\mathrm{Na}$ – sodium-24

${}^{4}_{2}\mathrm{He}$ – alpha particle (nucleus of a helium-4)

So, ${}^{A}_{Z}\mathrm{X} \rightarrow {}^{24}_{11}\mathrm{Na} + {}^{4}_{2}\mathrm{He}$, where X is an unknown element, A – atomic number, Z – mass number.

A = 24 + 4 = 28

Z = 11 + 2 = 13

Mass number 13 in the periodic table has aluminum. Thus, the unknown element is aluminium-28. The final nuclear equation is:

${}^{28}_{13}\mathrm{Al} \rightarrow {}^{24}_{11}\mathrm{Na} + {}^{4}_{2}\mathrm{He}$