VERSION 01 - GREY

1. In the reaction $N_2H_4(aq) + H_2O(l) \rightleftharpoons N_2H_5^+(aq) + OH^-(aq)$, which species are acids?

   A) $N_2H_4(aq)$ and $N_2H_5^+(aq)$
   B) $H_2O(l)$ and $N_2H_5^+(aq)$
   C) $N_2H_5^+(aq)$ and $OH^-(aq)$
   D) only $OH^-(aq)$
   E) only $N_2H_5^+(aq)$

2. At a given temperature, K = 0.020 for the equilibrium: $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$
   What is K for $2Cl_2(g) + 2PCl_3(g) \rightleftharpoons 2PCl_5(g)$

   A) 0.020
   B) 50
   C) 100
   D) 500
   E) 2500

   ↳ eqn is reversed ∴ $K \rightarrow \frac{1}{K}$
   eqn is multiplied by 2 ∴ $K \rightarrow K^2$
   ∴ $\left(\frac{1}{K}\right)^2 = \frac{1}{(0.020)^2} = 2500$

3. What volume of 0.500 M strontium nitrate ($Sr(NO_3)_2$) solution is needed to prepare 250.0 mL of a solution that is 0.200 M in nitrate?

   A) 25.0 mL
   B) 50.0 mL
   C) 75.0 mL
   D) 100. mL
   E) 125 mL

   $0.200 \frac{\text{moles}}{\text{L}} \times 0.2500\text{L} = 0.0500 \text{ moles } NO_3^-$

   $0.0500 \text{ moles } NO_3^- \times \frac{1 \text{ mole } Sr(NO_3)_2}{2 \text{ moles } NO_3^-} = 0.0250 \text{ moles } Sr(NO_3)_2$

   $0.0250 \text{ moles } Sr(NO_3)_2 \times \frac{1\text{L}}{0.500 \text{ moles } Sr(NO_3)_2} = 0.0500\text{L}$ OR 50.0mL

4. How many hydrogen atoms are present in 6.0 g of water?

   A) 2.0×10^{23}
   B) 4.0×10^{23}
   C) 7.2×10^{24}
   D) 1.1×10^{24}
   E) 0.66

   $6.0\text{g } H_2O \times \frac{1 \text{ mole } H_2O}{18.02\text{g } H_2O} \times \frac{2 \text{ moles H}}{1 \text{ mole } H_2O} \times \frac{6.02\times10^{+23} \text{ H atoms}}{1 \text{ mole H}}$

   $= 4.0 \times 10^{23}$ H atoms

5. Which of the following indicates the most acidic solution?

   A) $[OH^-] = 0.5$ M → pOH = 0.3 ∴ pH = 14.00 − 0.3 = 13.7 Basic! ✗ ↳ high $[H^+]$, low pH
   B) pH = 1.2 acidic
   C) $[H^+] = 0.3$ M → pH = 0.5 lowest
   D) pOH = 5.9 → pH = 14 − pOH = 8.1 (basic) ✗
   E) $[H^+] = 1.0\times10^{-4}$ M
      ↳ pH = $-\log[H^+]$ = 4.00

6. Consider the following: $2N_2O(g) + N_2H_4(g) \rightleftharpoons 3N_2(g) + 2H_2O(g)$
Initially there are 0.10 moles of N_2O and 0.25 moles of N_2H_4 in a 10.0 L container. If there are 0.06 moles of N_2O at equilibrium, how many moles of N_2 are present at equilibrium?

A) 0.9
B) 0.04
C) 0.06
D) 0.02
E) none of these

C

	$2N_2O$	$+ N_2H_4 \rightleftharpoons$	$3N_2$	$+ 2H_2O$	
I	0.10 mol	0.25 mol	0	0	10.0 L
C	$-2x$	$-x$	$+3x$	$+2x$	
E	0.06	$0.25-x$	$3x$	$2x$	

$0.10 - 2x = 0.06$

$2x = 0.02$

moles $N_2 = 3x$

$= 3(0.02)$

$= 0.06$

7. Write a balanced net ionic equation for the following reaction:
$HF(aq) + KOH(aq) \rightarrow KF(aq) + H_2O(l)$

A) $F^-(aq) + K^+(aq) \rightarrow KF(aq)$
B) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$
C) $H^+(aq) + KOH(aq) \rightarrow K^+(aq) + H_2O(l)$
D) $HF(aq) + OH^-(aq) \rightarrow F^-(aq) + H_2O(l)$
E) $HF(aq) + K^+(aq) + OH^-(aq) \rightarrow K^+(aq) + F^-(aq) + H_2O(l)$

D

weak acid / weak electrolyte ∴ doesn't dissociate

8. The formula for neodymium sulfate is $Nd_2(SO_4)_3$. On the basis of this information, the formula for the nitride of neodymium would be expected to be

A) $Nd_2(NO_2)_3$
B) Nd_3N_2
C) $Nd(NO_3)_3$
D) $Nd(NO_2)_3$
E) NdN

E

$Nd_2^{3+}(SO_4)_3^{2-}$

∴ $Nd^{3+}N^{3-}$

based on periodic table, group 15

9. For the reaction system: $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$; $K_c = 0.020$ at 720 K.
If the initial concentrations of HI, H_2 and I_2 are all 1.50×10^{-3} M at 720 K, which one of the following statements is correct?

A) The system is at equilibrium.
B) The $[H_2]$ and [HI] will decrease as the system is approaching equilibrium.
C) The [HI] will increase as the system is approaching equilibrium.
D) The [HI] and $[I_2]$ will increase as the system is approaching equilibrium.
E) The $[H_2]$ and $[I_2]$ will increase as the system is approaching equilibrium.

C

$Q = \frac{(H_2)(I_2)}{(HI)^2}$

$Q = \frac{(1.5\times10^{-3})(1.5\times10^{-3})}{(1.5\times10^{-3})^2}$

$Q = 1 > K$

∴ too many products
Rxn moves L←R

10. At 25°C and 1.00 atm pressure, it is found that 2.24 L of gas weighs 3.11 g.
Its relative molecular mass is

A) 34.0 g.
B) 3.11 g.
C) 37.1 g.
D) 28.5 g.
E) 31.1 g.

A

add 273.15 = 298.15 K

mass / mole

$PV = nRT$

$n = \frac{PV}{RT} = \frac{1.00\ atm \times 2.24\ L}{0.0821\ \frac{atm \cdot L}{K \cdot mole} \times 298.15\ K}$

$n = 0.0915$ moles

$MM = \frac{3.11\ g}{0.0915\ moles}$

$= 33.985$

$= 34.0\ g/mol$

11. In the reaction $2A + B \rightarrow 3C + D$, 3.0 moles of A and 2.0 moles of B react to form 4.0 moles of C. What is the percent yield for this reaction?

A) 50%
B) 67%
C) 75%
D) 89%
E) 100%

D

$3.0 \text{ mol A} \times \frac{3 \text{ mol C}}{2 \text{ mol A}} = \frac{9}{2}$ OR 4.5 mol C (LR)

$2.0 \text{ mol B} \times \frac{3 \text{ mol C}}{1 \text{ mol B}} = 6.0 \text{ mol C}$ Excess

$\%\text{ yield} = \frac{\text{actual}}{\text{theoretical}} \times 100\% = \frac{4.0}{4.5} \times 100\% = 88.88\%$

$= 89\%$

12. What is the percentage of nitrogen in ammonium phosphate, $(NH_4)_3PO_4$?

A) 11.6%
B) 16.0%
C) 28.2%
D) 31.9%
E) 34.3%

C

$MM_{(NH_4)_3PO_4} = 3(14.01) + 12(1.01) + 30.97 + 4(16.00) = 149.12 \text{ g/mole}$

$\%N = \frac{3(14.01 \text{ g/mol})}{149.12 \text{ g/mol}} \times 100\% = 28.19\% = 28.2\%$

13. The pH of a 0.0025 M aqueous solution of calcium hydroxide is

A) 11.70
B) 11.40
C) 12.00
D) 2.60
E) 2.30

A

$Ca(OH)_2 \rightarrow Ca^{2+} + 2(OH^-)$

I	0.0025	0	0
C	−0.0025	+0.0025	+2×0.0025
E	0	0.0025	0.0050 M

$pOH = -\log[OH^-] = 2.30$

$pH = 14.00 - 2.30 = 11.70$

14. Four identical 1.0 L flasks contain the gases He, Cl_2, CH_4 and NH_3 each at 0°C and 1 atm pressure. Which gas sample has the greatest number of molecules?

A) He
B) Cl_2
C) CH_4
D) NH_3
E) All gases have the same.

E

↳ Same V, T & P ∴ Same # moles = # molecules

15. Acid rain is produced by the following sequence of reactions:

$4FeS_2(s) + 11O_2(g) \rightarrow 2Fe_2O_3(s) + 8SO_2(g)$

$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(l)$

How many moles of H_2SO_4 will be produced from 5.00 moles of $FeS_2(s)$?

A) 10.0 moles
B) 20.0 moles
C) 5.00 moles
D) 12.2 moles
E) 6.11 moles

A

$5.00 \text{ mol } FeS_2 \times \underbrace{\frac{8 \text{ mol } SO_2}{4 \text{ mol } FeS_2}}_{\text{Rxn \#1}} \times \underbrace{\frac{2 \text{ mol } SO_3}{2 \text{ mol } SO_2}}_{\text{Rxn \#2}} \times \underbrace{\frac{1 \text{ mol } H_2SO_4}{1 \text{ mol } SO_3}}_{\text{Rxn \#3}}$

$= 10.0 \text{ mol } H_2SO_4$

16. A student is given a sample in the lab which contains one of the ions listed below.
After adding $AgNO_{3(aq)}$ to part of the unknown sample, the student got a greyish precipitate.
After adding $Mg(NO_3)_{2(aq)}$ to another part of the unknown sample, the student got a black precipitate.
Based on these observations, the only possible ion to be in the sample is:

D

A) Cl^- $+ Ag^+ \rightarrow AgCl_{(s)}$; $Cl^- + Mg^{2+} \rightarrow$ No Rxn
B) CH_3COO^- $+ Ag^+ \rightarrow$ NRxn ; $CH_3COO^- + Mg^{2+} \rightarrow$ No Rxn
C) ClO_4^- $+ Ag^+ \rightarrow$ NR ; $ClO_4^- + Mg^{2+} \rightarrow$ No Rxn
D) S^{2-} $+ Ag^+ \rightarrow Ag_2S$; $S^{2-} + Mg^{2+} \rightarrow MgS$
E) SO_4^{2-} $+ Ag^+ \rightarrow Ag_2SO_4$; $SO_4^{2-} + Mg^{2+} \rightarrow$ No Rxn

17. At 0°C, the ion-product constant of water, K_w is 1.2×10^{-15}. What is the pH of pure water at 0°C?

E

A) 7.00
B) 6.88
C) 7.56
D) 14.92
E) 7.46

$2H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$; $K_w = [H_3O^+][OH^-]$

$K_w = x^2$

$x = \sqrt{K_w}$

$\therefore [H_3O^+] = \sqrt{K_w} = 3.46\times10^{-8}$

$pH = -\log[H_3O^+]$

$\therefore pH = 7.46$

18. For the reaction, $PCl_{5(g)}$ (+ heat) $\rightleftharpoons$ $PCl_{3(g)} + Cl_{2(g)}$, which of the following is FALSE?

D

A) Adding PCl_3 to the container shifts the equilibrium to form more PCl_5. ✓ ← R
B) Increase the temperature shifts the equilibrium to form more PCl_3. ✓ → R
C) Decreasing the volume of the container shifts the equilibrium to form more PCl_5. ✓ ← R takes up less room
D) Removing PCl_5 from the container shifts the equilibrium to form more PCl_3. ✗ ← R to make more PCl_5
E) Changing the internal pressure has no effect on the system. ✓

19. Consider the reaction between 50.0 mL of 0.200 M sodium hydroxide and 75.0 mL of 0.100 M HCl.
Which of the following statements is correct?

B

A) NaOH is the limiting reagent. ✗
B) After the reaction, $[Na^+]$ is greater than $[OH^-]$. ✓
C) After the reaction, $[Na^+] = [Cl^-]$. ✗
D) After the reaction, $[Na^+] = 0.200$ M because Na^+ is a spectator ion. ✗
E) ~~None of these~~ are correct.

0.0100 moles ; 0.00750 moles

	$NaOH$	+ HCl	→ H_2O	+ $NaCl$
I	0.0100	Excess 0.0075 (LR)	—	0
C	−0.0075	−0.0075		+0.0075
E	0.0025 moles	0		0.0075 moles

not equal ($Na^+ = 0.0100$ moles, $Cl^- = 0.0075$ moles, $OH^- = 0.0025$ moles)

20. What volume of 0.350 M H_3PO_4 is required to react completely with 0.156 moles KOH?

A

A) 149 mL
B) 446 mL
C) 748 mL
D) 1340 mL
E) 2240 mL

$H_3PO_{4(aq)} + 3KOH_{(aq)} \rightarrow K_3PO_{4(aq)} + 3H_2O_{(l)}$

0.350 M ; 0.156 moles

$0.156 \text{ moles KOH} \times \frac{1 \text{ mole } H_3PO_4}{3 \text{ moles KOH}} \times \frac{1 \text{ L}}{0.350 \text{ moles } H_3PO_4} = 0.1486 \text{ L OR } 148.6 \text{ mL}$ OR 1.49 mL