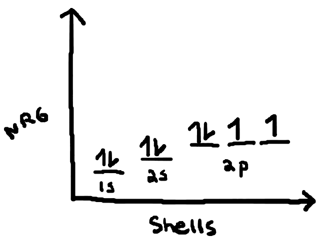
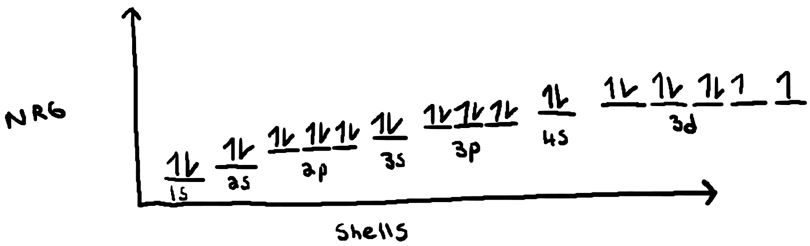
Chem Review Questions

January 19, 2021 8:57 PM

1. **oxygen**



Zinc (Zn^{2+})



2. Sn: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^2$

   Sn^{2+}: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10}$

3. Pb: $[xe] 6s^2 4f^{14} 5d^{10} 6p^2$

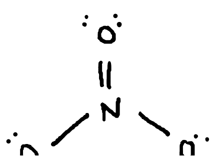
   Pb^{2+}: $[xe] 6s^2 4f^{14} 5d^{10}$

4. a) Ca has a greater radius than Co. Ca has less number of protons, so it has the lower effective nuclear charge. This means that each electron faces less attraction to the positive nucleus. Due to a decreased attraction of valence electrons in Ca than in Co, the valence electrons of Ca are not as tightly pulled towards the nucleus.

   b) Cl- has the greater radius than K+. Both ions have the same number of protons, but Cl- has one extra electron, and K+ has one less electron. As a result, Cl- has a lower effective nuclear charge. The greater number of valence electrons in Cl- will each face a smaller fraction of the total attraction exerted by the protons. Thus, the valence electrons of Cl- will orbit farther from the nucleus compared to those of K+.

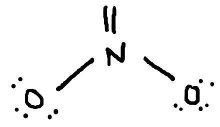
5. Aluminium has a lower effective nuclear charge than magnesium. This means that each valence electron of aluminium faces less attraction to the positive nucleus. This lower attraction makes Aluminium's valence electrons orbit farther from the nucleus, so less energy is required to remove one valence electron from its orbitals than to remove one from magnesium.

6. 1
   5
   +18



6.

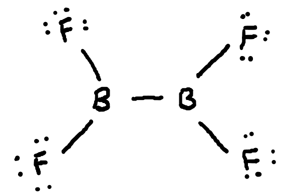
$$\begin{array}{r} 5 \\ + 18 \\ \hline 24 \end{array}$$



7.

$$\begin{array}{r} 3 \\ 3 \\ 7 \\ 7 \\ 7 \\ + 7 \\ \hline 34 \end{array}$$

Lewis :

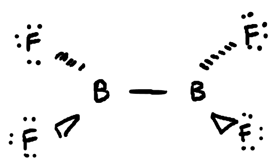


Boron is an exception :

- B forms 3 single bonds rather than 4, so it can't fill its octet.
- It bonds covalently with non metals even though it is found on the left
- cannot form double bonds due to low electronegativities

VESPR

- Trigonal Planar
- AX_3



8. a)

Butane has the highest boiling point. It has the greatest number of carbon to carbon bonds, so more intermolecular forces are present. The more London Dispersion Forces present, the more energy is required to overcome its attractive forces to form a gas.

Ethane : C - C

Methane : C

Butane : C - C - C - C

Prop. : C - C - C

b)

NaCl has the highest boiling point as it is an ion. Ionic bonds are the strongest type of intramolecular forces, meaning that they need the more energy overcome their attractive forces to become a gas.

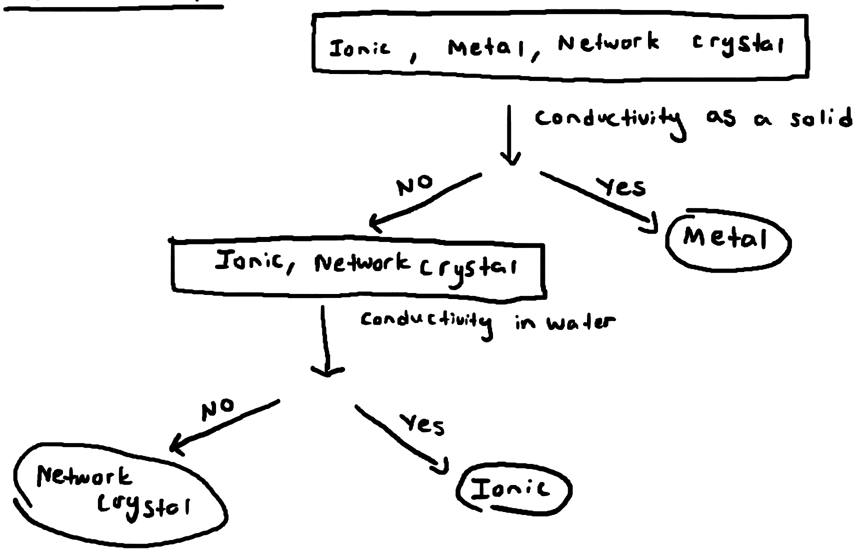
Water : H - O - H

Methane : C

Sodium Chloride : NaCl

Hydrogen Cyanide : H - C ≡ N

9. **Test flowchart:**



10.

$n \cdot \Delta H_{rxn} = -mc\Delta t$

$n \cdot -37\,000 = -(200)(4.18)(6)$

$n = 0.1356$ mol

$n = 0.1356$ mol

$MM = 42.394$ g/mol

$m = n \cdot MM$

$= (0.1356)(42.394)$

$\boxed{= 5.75\text{ g}}$

∴ 5.75 grams of LiCl is needed.

11.

$$\cancel{4C} + \cancel{4O_2} \longrightarrow 4\cancel{CO_2} \qquad \Delta H^\circ = -393.5 \text{ kJ}$$

$$\cancel{4CO_2} + \cancel{5H_2O} \longrightarrow C_4H_{10} + \cancel{6.5O_2} \qquad \Delta H^\circ = 2657.4 \text{ kJ}$$

$$+ \quad 5H_2 + \cancel{2.5O_2} \longrightarrow \cancel{5H_2O} \qquad + \ \Delta H^\circ = -483.6 \text{ kJ}$$

$$4C + 5H_2 \longrightarrow C_4H_{10} \qquad \Delta H^\circ = 1780.3 \text{ kJ}$$

∴ Enthalpy change for the formation of one mol of butane gas is 1780.3 kJ/mol.

12.

a) $N_{2(g)} + 3H_{2(g)} \longrightarrow 2NH_{3(g)}$

$$N_2 + \cancel{3H_2O} \longrightarrow 2NH_3 + \cancel{1.5O_2} \qquad \Delta H^\circ = 765 \text{ kJ}$$

$$\oplus \quad 3H_2 + \cancel{1.5O_2} \longrightarrow \cancel{3H_2O} \qquad \oplus\ \Delta H^\circ = -864 \text{ kJ}$$

$$N_2 + 3H_2 \longrightarrow 2NH_3 \qquad \Delta H = \frac{-99 \text{ kJ}}{2}$$

$\boxed{= -49.5 \text{ kJ/mol}}$

∴ The enthalpy of formation of ammonia is −49.5 kJ/mol.

b) $N_{2(g)} + O_{2(g)} \longrightarrow 2NO_{(g)}$

$$N_2 + \cancel{3H_2O} \longrightarrow \cancel{2NH_3} + 1.5\,O_2 \qquad \Delta H^\circ = 765 \text{ kJ}$$

$$\oplus \quad \cancel{2NH_3} + 2.5\,O_2 \longrightarrow 2NO + \cancel{3H_2O} \qquad \Delta H^\circ = -585 \text{ kJ}$$

$$N_2 + O_2 \longrightarrow 2NO \qquad \Delta H = \frac{180 \text{ kJ}}{2}$$

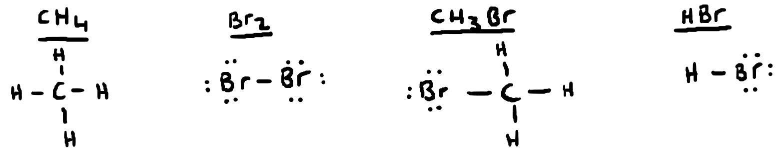
$\boxed{= 90 \text{ kJ/mol}}$

The enthalpy of formation of nitrogen monoxide

$\boxed{= 90\ kJ/mol}$

∴ The enthalpy of formation of nitrogen monoxide is 90 kJ/mol.

13.



Reactants			Products		
4×	C−H	413 kJ/mol	3×	C−H	413 kJ/mol
1×	Br−Br	193 kJ/mol	1×	C−Br	209 kJ/mol
			1×	H−Br	366 kJ/mol

$$\Delta H_{rxn} = \left[\sum (4\cdot 413) + (1\cdot 193)\right] - \left[\sum (3\cdot 413) + (1\cdot 209) + (1\cdot 366)\right]$$

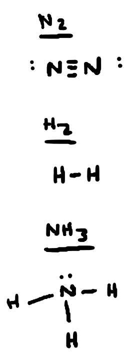
$= 1845 - 1814$

$\boxed{= 31\ kJ}$

∴ The enthalpy change for the reaction is 31 kJ.

14.

$$N_2 + 3H_2 \longrightarrow 2\ NH_3$$



React			Product		
1×	N≡N	945 kJ	6×	N−H	?
3×	H−H	436 kJ			

* The bond enthalpy of N_2 is significantly higher than that of H_2. This is because N_2 involves a triple bond while H_2 has a single bond. (see diagrams on left)

$$-46\cdot 2 = \left[\sum (945) + (3\cdot 436)\right] - \left[\sum (6\cdot x)\right]$$

$$-92 = 2253 - 6x$$

$$-2345 = -6x$$

$$x = 390.83\ kJ/mol$$

∴ The average bond enthalpy of the N−H bond is 391 kJ/mol.

15.

$$CaO_{(s)} + H_2O_{(l)} \longrightarrow Ca(OH)_{2\,(s)}$$

Enthalpy of formation reactions

CaO: $Ca + \frac{1}{2}O_2 \rightarrow CaO$ $\Delta H = -636\ kJ/mol$

H_2O: $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$ $\Delta H = -286\ kJ/mol$

$Ca(OH)_2$: $Ca + O_2 + H_2 \rightarrow Ca(OH)_2$ $\Delta H = -987\ kJ/mol$

$$\left[\sum (\ldots H_f^\circ\ Ca(OH)_2)\right] - \left[\sum (1\cdot H_f^\circ CaO) + (1\cdot H_f^\circ H_2O)\right]$$

$$\Delta H_{rxn} = \left[\sum (1 \cdot H_f^\circ\ Ca(OH)_2)\right] - \left[\sum (1 \cdot H_f^\circ\ CaO) + (1 \cdot H_f^\circ\ H_2O)\right]$$

$$= \left[\sum (1 \cdot -987)\right] - \left[\sum (1 \cdot -636) + (1 \cdot -286)\right]$$

$$\boxed{= -65\ kJ/mol}$$

16. a)

$$HNO_2 + \cancel{H^+} \longleftrightarrow H_2O + \boxed{\cancel{NO^+}}$$

$$NH_4^+ \longleftrightarrow \boxed{\cancel{NH_3}} + \cancel{H^+}$$

$$\boxed{\cancel{NO^+}} + \boxed{\cancel{NH_3}} \longrightarrow \boxed{\cancel{NH_3NO^+}}$$

$$+ \quad \boxed{\cancel{NH_3NO^+}} \longrightarrow H_2O + H^+ + N_2$$

$$HNO_2 + NH_4^+ \longrightarrow 2\,H_2O + H^+ + N_2$$

▭ = intermediate

◇ = catalyst

b) NO^+, NH_3, NH_3NO^+

c) iv. $NH_3NO^+ \longrightarrow H_2O + H^+ + N_2$

d) Yes. The catalyst is H^+

17.

$$H_2 + F_2 \rightleftharpoons 2\,HF$$

	H_2	F_2	$2\,HF$
I	1	1	0
C	$-x$	$-x$	$+2x$
E	$1-x$	0.24	$2x$

$1 - x = 0.24$

$\boxed{x = 0.76}$

$\therefore$ $[H_2] = 1 - 0.76 = 0.24$ mol/L

$[HF] = 2(0.76) = 1.52$ mol/L

18.

$$k_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

$$= \frac{(2\times10^{-4})^2}{(1.5\times10^{-5})(3.45\times10^{-1})^3}$$

$$= \frac{4\times10^{-8}}{6.16\times10^{-7}}$$

$\therefore$ K_c is 0.065

$$\boxed{= 0.065}$$

19.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

$$Q = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

$$= \frac{(2.2\times10^{-4})^2}{(4)(2\times10^{-2})^3}$$

$$= \frac{4.84\times10^{-8}}{3.2\times10^{-5}}$$

$$= 1.51\times10^{-3}$$

$$\boxed{Q = 0.00151}$$

$\because Q < k_c$

$\therefore$ It is not at equilibrium. The reaction will proceed in the forward direction.

20.

	H_2	F_2	$\rightleftharpoons 2HF$
I	2	2	3
C	$-x$	$-x$	$+2x$
E	$2-x$	$2-x$	$3+2x$

$$k_c = \frac{[HF]^2}{[H_2][F_2]}$$

$$\sqrt{1.15\times10^2} = \frac{\sqrt{(3+2x)^{\cancel{2}}}}{\sqrt{(2-x)^{\cancel{2}}}}$$

$$10.72 = \frac{3+2x}{2-x}$$

$$(10.72)(2-x) = 3+2x$$

$$21.44 - 10.72x = 3+2x$$

$$18.44 = 12.72x$$

$$\boxed{x = 1.45}$$

$\therefore [H_2] = [F_2] = 2 - 1.45 = 0.55$ mol/L

$[HF] = 2(1.45) = 5.9$ mol/L

21.

$$MgF_{2(s)} \rightleftharpoons Mg^{2+}_{(aq)} + 2F^-_{(aq)}$$

1 : 1 : 2

$$k_{sp} = [Mg^{2+}][F^-]^2$$

$$= (2.76\times10^{-4})(5.52\times10^{-4})^2$$

$$\boxed{= 8.41\times10^{-11}}$$

convert Solubity from g/mL to mol/L

$$= \frac{0.00172\,\cancel{g}}{100\,\cancel{mL}} \cdot \frac{1000\,\cancel{mL}}{1\ L} \cdot \frac{1\ mol}{62.3018\,\cancel{g}}$$

$$= \frac{1.72\ mol}{6230.18\ L}$$

$$= 2.76\times10^{-4}\ mol/L$$

$\therefore$ ksp of magnesium fluoride is 8.41×10^{-11}

22.

$$CaSO_4 \rightleftharpoons Ca^{2+} + SO_4^{2-}$$

$$[CaCl_2] = \frac{(0.1)(0.1)}{0.2} \qquad [Na_2SO_4] = \frac{(0.1)(0.0400)}{0.2}$$

$= 0.05$ mol/L $\uparrow$ $[Ca]$

$= 0.02$ mol/L $\uparrow$ $[SO_4]$

$Q = [Ca^{2+}][SO_4^{2-}]$

$= (0.05)(0.02)$

$Q = 1 \times 10^{-3}$

$\because Q > K_{sp}$

$\therefore$ A precipitate will form

23.

	$PbCl_{2(s)} \rightleftharpoons$	$Pb^{2+}_{(aq)}$ +	$2\,Cl^-_{(aq)}$
I		0	0.2
C		$+x$	$+2x$
E		x	$0.2 + \cancel{2x}$

← Ignore b/c ksp is so small

Assumption

$= \frac{3 \times 10^{-4}}{0.1} \times 100\%$

$= 0.3\% < 5\%$

$\therefore$ Assumption is valid.

$1.2 \times 10^{-5} = (x)(0.2)^2$

$1.2 \times 10^{-5} = 0.04x$

$\boxed{x = 3 \times 10^{-4} \text{ mol/L}}$

$\therefore$ Molar solubility of $PbCl_2$ in 0.2 mol/L NaCl is 3×10^{-4} mol/L

25.

$$\overset{1}{NaOH} \rightleftharpoons \overset{1}{Na^{+1}} + \overset{1}{OH^-}$$

strong base

1 : 1 : 1

$m = 2.6g$

$MM = 39.997\ g/mol$

$n = \frac{m}{MM}$

$n = \frac{2.6\ g}{39.997\ g/mol}$

$\boxed{n = 0.065 \text{ mol}}$

$c = \frac{0.065 \text{ mol}}{0.5 \text{ L}}$

$\boxed{c = 0.13 \text{ mol/L}}$ ⟶ 0.13 mol/L

$k_w = [OH^-][H^+]$

$1 \times 10^{-14} = (0.13)[H^+]$

$\boxed{[H^+] = 7.69 \times 10^{-14} \text{ mol/L}}$

$\therefore [H^+] = 7.69 \times 10^{-4}$ mol/L

$[OH^-] = 0.13$ mol/L

26.

$HNO_3 \rightleftharpoons H^+ + NO_3^-$

0.042 mol/L   0.042 mol/L

pH

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

$pH = -\log(0.042)$

$\boxed{pH = 1.38}$

pOH

$pH + pOH = 14$

$1.38 + pOH = 14$

$\boxed{pOH = 12.62}$

$[OH^-]$

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

$12.62 = -\log[OH^-]$

$[OH^-] = 10^{-12.62}$

$\boxed{[OH^-] = 2.40 \times 10^{-13} \text{ mol/L}}$

$\therefore$ pH is 1.38, pOH is 12.62, $[OH^-]$ is 2.40×10^{-13} mol/L

27.

$CH_3COOH \rightleftharpoons CH_3COO^- + H_3O^+$

	CH_3COOH	CH_3COO^-	H_3O^+
I	0.1	0	0
C	$-x$	$+x$	$+x$
E	$0.1-x$	x	x

Sub in

$$\% \text{ ionization} = \frac{[\text{acid ionized}]}{[\text{acid solute}]} \times 100$$

$$1.3 = \frac{[H_3O^+]}{0.1} \times 100$$

$[H_3O^+] = x = 1.3 \times 10^{-3}$ mol/L

$$K_a = \frac{[H_3O^+][CH_3COO^-]}{[CH_3COOH]}$$

$$= \frac{(x)(x)}{0.1-x}$$

$$= \frac{(1.3 \times 10^{-3})^2}{0.1 - 1.3 \times 10^{-3}}$$

$$\boxed{= 1.71 \times 10^{-5}}$$

$\therefore$ The acid ionization constant is 1.71×10^{-5}

28.

$HC_4H_3N_2O_3 \rightleftharpoons C_4H_3N_2O_3^- + H^+$

	$HC_4H_3N_2O_3$	$C_4H_3N_2O_3^-$	H^+
I	0.25	0	0

	$HC_4H_3N_2O_3$	$\rightleftharpoons$ $C_4H_3N_2O_3$	
I	0.25	0	0
C	$-x$	$+x$	$+x$
E	$0.25 - \cancel{x}$ ← ignore	x	x

$$k_a = \frac{[H_3O^+][C_4H_3N_2O_3]}{[HC_4H_3N_2O_3]}$$

$$9.8\times10^{-5} = \frac{x^2}{0.25}$$

$$x = 4.95\times10^{-3}\ mol/L$$

$$\boxed{[H^+] = 4.95\times10^{-3}\ mol/L}$$

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

$pH = -\log(4.95\times10^{-3})$

$\boxed{pH = 2.31}$

∴ The $[H^+]$ is 4.95×10^{-3} mol/L, and the pH is 2.31.

Electrochem - To be done later

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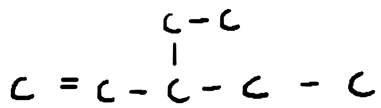
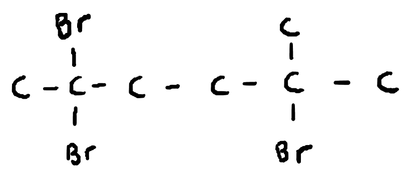
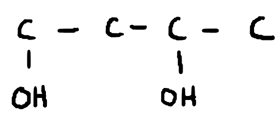
34. a)



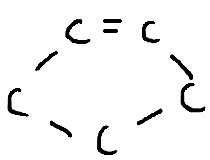
b)



c)



d)

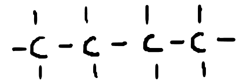


35. Structural isomers - Same molecular formula, but different arrangements of bonds among the atoms

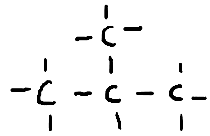
ie/

arrangements of bonds among the atoms

ie/



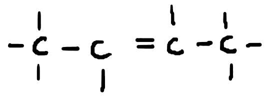
C_4H_{10}



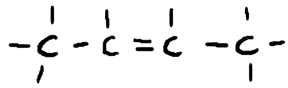
C_4H_{10}

<u>Geometric isomer</u> - Same molecular formula and Same arrangements of bonds among the atoms. They only differ by the spatial orientation of atoms.

ie/

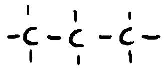


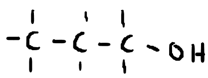
C_4H_8
trans isomer

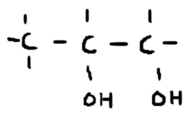


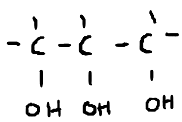
C_4H_8
cis isomer

36.

a) Propane 

b) Propanol 

c) Propan-1,2-diol 

d) Propan-1,2,3-triol 

37.

$$CH_{4(g)} + 2O_{2(g)} \longrightarrow 2H_2O_{(l)} + CO_{2(g)}$$

If there is limited oxygen, incomplete combustion would occur, and carbon monoxide and carbon soot would also be produced.

$$4CH_{4(g)} + 6O_{2(g)} \longrightarrow 8H_2O_{(l)} + CO_{2(g)} + 2CO_{(g)} + C_{(s)}$$