KEY-1

Bonding Unit Review

1. Copy and complete the following table.

Element name	Lewis symbol	Group number	Number of valence electrons	Number of lone pairs	Number of bonding electrons
calcium	$\dot{Ca}\cdot$	2	2	0	2
aluminium	$\dot{Al}\cdot$	13	3	0	3
arsenic	$\cdot\ddot{As}\cdot$	15	5	1	3
oxygen	$\cdot\ddot{O}:$	16	6	2	2
bromine	$\cdot\ddot{Br}:$	17	7	3	1
neon	$:\ddot{Ne}:$	18	8	4	0

2. (a) State the types of elements expected to react to form compounds containing covalent bonds.
   Non-metals

   (b) State the types of elements expected to react to form compounds containing ionic bonds.
   Metals and non-metals

   (c) Explain your answers to (a) and (b) using the concept of electronegativity.

   Non-metals have high electronegativity so when non-metals react, they share electrons because neither non-metal can take electrons away from the other. Sharing electrons results in a covalent bond

   Metals have low electronegativity. When a metal reacts with a non-metal, the metal loses and electron to the non-metal. This creates positive and negatively charged ions which form an ionic bond.

3. Using Lewis symbols and formulas, write the formation equation for each of the following compounds.
   (a) potassium bromide

   $$\dot{K} + \cdot\ddot{Br}: \rightarrow [K]^{+} [:\ddot{Br}:]^{-1}$$

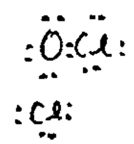
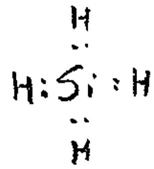
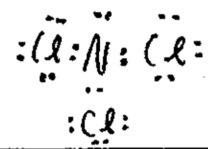
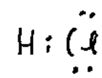
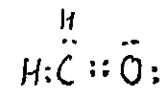
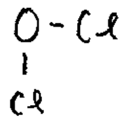
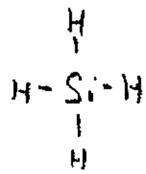
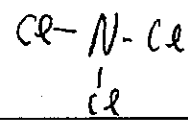
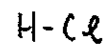
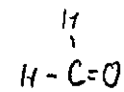
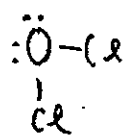
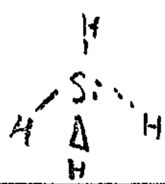
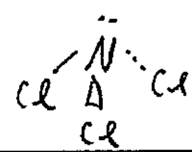
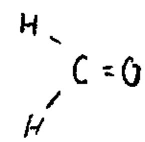
   (b) sodium oxide

   $$\dot{Na} + \cdot\ddot{O}: \rightarrow [Na]^{+}_{2} [:\ddot{O}:]^{2-}$$

   (c) calcium fluoride

   $$\dot{Ca}\cdot + \cdot\ddot{F}: \rightarrow [Ca]^{+2} [:\ddot{F}:]^{-1}_{2}$$

4. For each of the following molecular formulas, draw the Lewis, structural, and stereochemical formulas, and state the shape around the central atom.
(a) OCl_2 (b) SiH_4 (c) NCl_3 (d) HCl (e) CH_2O

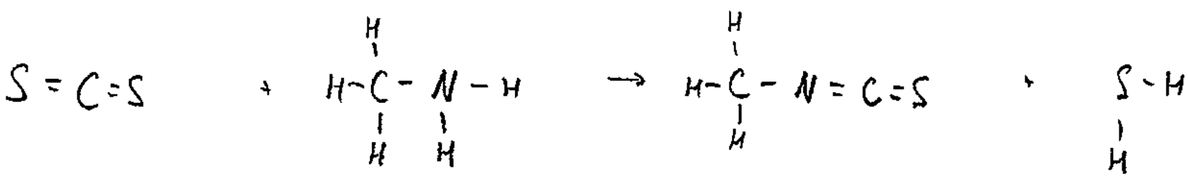
	OCl_2	SiH_4	NCl_3	HCl	CH_2O
Lewis					
Structural					
Shape					
Shape Name	v-shape	tetrahedral	trigonal pyramid	linear	trigonal planar

5. Classify each of the molecules represented in the previous question as polar or nonpolar.

OCl_2 - polar **SiH_4 – non-polar** **NCl_3 - polar** **HCl - polar** **CH_2O - non-polar**

6. Methylisocyanate is a toxic pesticide that is manufactured using the following chemical reaction.
$CS_2 + CH_3NH_2 \longrightarrow CH_3NCS + H_2S$

Rewrite this chemical equation using structural formulas for all reactants and products.



7. Define the three types of intermolecular forces. For each type of force, state how you would know if this type of force is likely present among molecules of a substance.

London dispersion	- attraction of protons in one molecule for electrons in another - All molecules have this type of attraction present
Dipole-Dipole	- attraction of a positive pole of one molecule for the negative pole of another - polar molecules have this type of attraction
Hydrogen bonding	- the positive hydrogen end of one molecule attracting the negative oxygen, fluorine or nitrogen end of another molecule - molecules containing an H bonded to an O, F, or N atom

Gases Unit Review

1. Complete the following statements.
(a) At a constant temperature and chemical amount of gas, as the pressure increases, the volume decreases.
(b) At a constant pressure and chemical amount of gas, as the temperature decreases, the volume increases.
(c) At a constant volume and temperature, if the chemical amount of gas inside a container is increased, the pressure increases.

2. Convert 95.8 kPa into units of millimetres of mercury and atmospheres.

$\frac{101.325\,kPa}{760\,mmHg} = \frac{95.8\,kPa}{x}$ $x = 718.559\,mmHg$ $= 719\,mmHg$

$\frac{1\,atm}{101.325\,kPa} = \frac{x}{95.8\,kPa}$ $x = 0.9454...$ $= 0.945\,atm$

3. A 1.5 L volume of gas is compressed at a constant temperature from 1.0 atm to 5.0 atm. Calculate the final volume.

$P_1V_1 = P_2V_2$

$(1.0\,atm)(1.5\,L) = (5.0\,atm)(V_2)$ $V_2 = 3.3\,L$

4. A balloon can hold 800 mL of air before breaking. A balloon at 4.0 °C containing 750 mL of air is allowed to warm up. Assuming a constant pressure inside the balloon, determine the minimum Celsius temperature when the balloon breaks.

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\frac{750\,mL}{277\,k} = \frac{800\,mL}{T_2}$ $T_2 = 295.46...\,k\ -273$ $= 22°C$

5. A sample of argon gas at 101 kPa and 22.0 °C occupies a volume of 150 mL. If the volume doubles at a temperature of 150°C, determine the new pressure.

$P_1V_1T_2 = P_2V_2T_1$

$P_2 = \frac{P_1V_1T_2}{V_2T_1} = \frac{(101\,kPa)(150\,mL)(427\,k)}{(300\,mL)(295\,k)} = 72.4\,kPa$

6. Using the kinetic molecular theory, explain Boyle's and Charles' laws.

Boyles Law - Gases can be compressed because they consist largely of empty space, this allows the molecules to be pressed closer together, reducing their volume

Charles law – gas molecules are always in motion, increasing the temperature of gas molecules gives them more energy. As a result, they move faster and expand their volume

7. Many people use propane barbeques for outdoor cooking. Predict the volume of carbon dioxide produced when 15 L of propane completely burns at SATP.

$\underline{1}C_3H_{8(g)} + \underline{5}O_{2(g)} \rightarrow \underline{3}CO_{2(g)} + \underline{4}H_2O_{(g)}$

$V = 15L$ $V = \frac{3}{1} \times 15L$ $= 45L$

8. Describe and compare the behaviour of real and ideal gases using the kinetic molecular theory.

9. Predict the volume that 25.0 g of oxygen gas would occupy at 22.0 °C and 98.1 kPa.

$PV = nRT$

$n = \frac{25.0\,g}{32.00\,g/mol} = 0.78125\,mol$

$V = \frac{nRT}{P} = \frac{(0.781...\,mol)(8.31\frac{kPa\cdot L}{mol\cdot k})(295\,k)}{98.1\,kPa} = 19.5\,L$

10. Compare the volume that 0.278 mol of hydrogen would occupy at STP and SATP.

@ STP $V = nV_m$
$= (0.278\,mol)(22.4\,L/mol)$
$= \boxed{6.23\,L}$

@ SATP $V = nV_m$
$= (0.278\,mol)(24.8\,L/mol)$
$= \boxed{6.89\,L}$

11. An average bungalow requires about 400 kmol of methane per year for space heating.
    a. Determine the volume of methane at SATP used in one year.

$V = nV_m = (400000\,mol)(24.8\,L/mol) = 9920000\,L$
$= \boxed{9.92\,ML \text{ or } 9.92 \times 10^6\,L}$

    b. Predict the volume of methane used if the pressure is 98.5 kPa and the temperature is 12.7 °C.

$V = \frac{nRT}{P} = \frac{(400{,}000\,mol)(8.31\,\frac{kPa \cdot L}{mol \cdot K})(285.7\,K)}{98.5\,kPa} = 9641287.31\,L = \boxed{9.64\,ML \text{ or } 9.64 \times 10^6\,L}$

Solutions, Acids and Bases Unit Review

1. Describe a homogeneous mixture and provide several examples.
   A mixture in which the different parts are not distinguishable.
   Ex. Tap water, apple juice, tea, coffee, etc.

2. Distinguish between electrolytes and non-electrolytes, including examples of types of substances in each category.
   Electrolytes – solutes that, when dissolved in water, can conduct electricity (ionic compounds, acids, bases)
   Non-electrolytes - solutes that, when dissolved in water, cannot conduct electricity (molecular compounds)

3. Explain, in terms of breaking and forming bonds, why the dissolving of substances in water can be either exothermic or endothermic.
   The breaking of bonds (absorbs energy) and forming of bonds (releases energy) always occurs when a substance dissolves. If the breaking of bonds absorbs more energy than the forming of bonds releases, the dissolving process is endothermic. Vice versa for exothermic.

4. Compounds may be ionic or molecular and may also be acids, bases, or neutral compounds.
   (a) Design an experiment to classify the solute in each of a number of different solutions.

   (b) Outline the expected results.

5. Write dissociation or ionization equations for the following pure substances dissolving in water.
   (a) lithium phosphate solid

$Li_3PO_{4(s)} \rightarrow 3Li^{+}_{(aq)} + PO_4{}^{3-}_{(aq)}$

   (b) hydrogen chloride gas

$HCl_{(g)} \rightarrow H^{+}_{(aq)} + Cl^{-}_{(aq)}$

   (c) aluminium sulfate solid

$Al_2(SO_4)_{3(s)} \rightarrow 2Al^{3+}_{(aq)} + 3SO_4{}^{2-}_{(aq)}$

6. Suppose you are given four unlabelled beakers, each containing a colourless aqueous solution of one solute. The possible solutions are NaCl(aq), HCl(aq), $BaCl_2$(aq), and CH_3Cl(aq). Write a series of diagnostic tests to distinguish each solution from the others.

7. A household cleaner contains 12.5 g of sodium hypochlorite in 500 mL of solution. Determine the percentage mass by volume concentration of this solution.

$\% \, w/v = \frac{m_{solute} (s)}{V_{solution} (mL} \times 100 = \frac{12.5g}{500mL} \times 100 = 2.5\% \, w/v$

8. A drain cleaner contains 2.75 mol/L sodium hydroxide. Calculate the volume of solution that contains 0.375 mol of sodium hydroxide.

$c = \frac{n}{V}$ $V = \frac{n}{c} = \frac{0.375 mol}{2.75 mol/L} = 0.1363.. L$ = 0.136L

9. A windshield washer solution was prepared by dissolving 100 g of methanol in water to form 2.00 L of solution. Calculate the amount concentration of the solution.

$n = \frac{m}{M} = \frac{100g}{32.05 g/mol} = 3.1201.. mol$ $c = \frac{n}{V} = \frac{3.1201.. mol}{2.00 L}$ = 1.56 mol

10. For an experiment, 100 mL of a 0.251 mol/L calcium chloride solution is required.
(a) Calculate the mass of calcium chloride that needs to be measured.

$n = cV = (0.251 mol/L)(0.100L) = 0.0251 mol$ | $m = nM = (0.0251 mol)(110.98 g/mol)$ = 2.79g

(b) Write a specific procedure for an untrained laboratory technician to prepare this solution.

11. Predict the volume of concentrated, 14.6 mol/L phosphoric acid required to prepare 250 mL of a 0.375 mol/L solution.

$C_1V_1 = C_2V_2$

$(14.6 mol/L)(V_1) = (0.375 mol/L)(250 mL)$ $V_1 = 6.42 mL$

12. Calculate the amount concentration of each ion in a 2.1 mol/L solution of iron(III) chloride? properties.

13. Write the acid formula for each of the following substances.
   (a) aqueous hydrogen bromide
   HBr
   (b) aqueous hydrogen sulphite
   H_2SO_3
   (c) hydrofluoric acid
   HF
   (d) sulfuric acid
   H_2SO_4

14. Complete the following table.

$[H_3O^+(aq)]$ (mol/L)	pH	Acidic/basic/neutral
1.0×10^{-7}	7	N
1.0×10^{-8}	8	B
2.0×10^{-4}	3.7	A
6.23×10^{-9}	8.21	B

15. The pH of pure water is 7, of carbonated water about 5, and of a cola drink about 3. How many times more acidic is a cola drink than carbonated water and pure water?

   100 times more acidic than carbonated H_2O

   10,000 times more acidic than pure H_2O

16. Use the modified Arrhenius theory to write chemical equations explaining the following evidence.
   (a) A vinegar solution is acidic.

   $CH_3COOH + H_2O_{(l)} \rightarrow CH_3COO^- + H_3O^+$

   (b) A baking soda (sodium hydrogen carbonate) solution has a pH of 8.

   $NaHCO_{3(s)} \rightarrow Na^+ + HCO_{3(aq)}^-$ $HCO_3^- + H_2O_{(l)} \rightarrow H_2CO_3 + OH^-$

   (c) Some muriatic (hydrochloric) acid is neutralized with a lye (sodium hydroxide) solution.

   $H_3O^+ + OH^- \rightarrow H_2O_{(l)}$

17. A simple window cleaning solution containing 0.25 mol/L ammonia has a pOH of 2.5.
   (a) Convert the pOH into an amount concentration of hydroxide ions.

   $[OH^-] = 10^{-pOH} = 10^{-2.5} = 0.003$ mol/L

   (b) Write a balanced chemical equation to explain this basic solution.

   $NH_3 + H_2O_{(l)} \rightarrow NH_4^+ + OH^-_{(aq)}$

   (c) Is ammonia a strong or weak base? Justify your answer.

   weak base

18. Polyprotic acids and bases occur naturally and are manufactured for a variety of purposes. Distinguish between monoprotic and polyprotic acids and bases.