SC 119 PRACTICE Assessment - ANSWERS:

1. Outdoor grilling is a very popular method of cooking. Propane is the gas that is commonly used in grills. Three things are required for a gas grill to ignite: gas, oxygen from the air and a spark. When the grill is turned on, propane is delivered to the igniter, where it reacts with oxygen (burns). The process of burning propane is called combustion. It can be represented by the following equation:

C_3H_8 + O_2 → CO_2 + H_2O
propane oxygen carbon dioxide water

a) Looking at the information given above, is the combustion of propane a chemical or physical change? Explain your reasoning.

It is a chemical reaction, because atoms that make up reactants are rearranged and new substances are formed with different properties

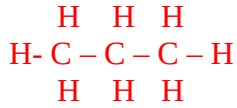
b) Balance the equation.

C_3H_8 + $5O_2$ → $3CO_2$ + $4H_2O$

c) Is propane an ionic or covalent compound? Provide evidence to support your conclusions.

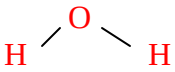
Propane is a covalent compound. It consists of atoms of carbon and hydrogen. Carbon and hydrogen have about the same attraction to shared electrons which is represented by their electronegativity values, C = 2.5 and H = 2.1. Carbon atom has slightly greater attraction for shared electrons, but it is not significant enough to cause permanent shift of electron cloud, and definitely not enough for complete transfer of valence electron(s).

d) Draw the Lewis structure for propane.



e) Draw the Lewis structure for carbon dioxide.

f) Looking at the information given above, find one example of a polar compound. Explain why it is polar. Be sure to discuss the polarity of bonds and the overall shape/symmetry of the molecule.



H_2O – water is a polar covalent compound because two lone pairs on the oxygen and two bonding pairs between oxygen and hydrogen atoms repel each other causing water molecule to obtain bent shape; also, oxygen has significantly higher electronegativity (attraction for shared electrons) than hydrogen 3.5 vs 2.2, which causes permanent shift of electron cloud towards oxygen and as a result formation of partial weak negative charge on the oxygen end, δ^-, and partial weak positive charge on the hydrogens end, δ^+

g) Looking at the information given above, find one example of a nonpolar compound. Explain why it is nonpolar. Be sure to discuss the polarity of bonds and the overall shape/symmetry of the molecule.

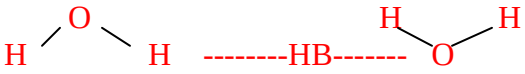
O = C = O

Although the elctronegativity difference between oxygen and carbon is significant, the absence of lone pairs at the central atom results in a symmetrical position of two oxygen atoms around carbon, which means that shared electrons are pulled by the nuclei of oxygen atoms with equal force, causing overall polarity of the molecule to be non-polar.

h) At room temperature (72 ^oF) propane is a gas and water is a liquid. This means that 72 ^oF must be higher than the boiling point for propane, but lower than the boiling point for water. Explain why propane has a lower boiling point than water. Provide an analysis of the interparticle forces between two molecules of propane and interparticle forces between two molecules of water and use these analyses to support your answer.

Temperature is a measure of kinetic energy of particles.
Molecules of propane are non-polar and forces that are responsible for holding these molecules together in a liquid or solid state are London Dispersion Forces. LDF is a result of short-lived charges caused by constant movement of electrons within molecules. These forces are very weak and not a lot of energy is required to overcome them to achieve gaseous state.

On a contrast, water molecules are held together by hydrogen bond attraction (attraction of partially negatively charged lone pairs on oxygen of one molecule to the partially charged hydrogen of another water molecule), which is a relatively strong force. To convert liquid water to gas requires more energy.



2. Aluminum chloride is frequently used as an active ingredient in antiperspirants. It reacts with particular components in sweat to form a gel plug in the duct of the sweat gland. The plugs prevent sweat from reaching the surface of the skin.

a) Is aluminum chloride an ionic or covalent compound? How does the [ionic or covalent, depending on what you selected] bond form?

It is an ionic compound. Aluminum is a metal that has three valence electrons and low attraction for electrons. In order for it to achieve stable octet it needs to lose these valence electrons (previous energy level has 8 electrons).

Chlorine is a non-metal that has seven valence electrons. To achieve octet it needs one more electron. Also, chlorine has high attraction for electrons.

a) Draw the Bohr model for an aluminum atom. Show the number of protons and electrons and show where they are found in the atom.

$13\ p^+$)2e)8e)3e

b) How many valence electrons does an aluminum atom have?

3 ve

c) What ion will aluminum form (provide the charge) and WHY will this ion form? Explain the chemical rationale for why an atom would form an ion.

Aluminum atom is neutral; it has 13 p^+ and 13 e^-. When 3 electrons are given up to another atom with stronger attraction for them, the number of protons doesn't equal number of electrons any more, resulting in an overall charge of 3+

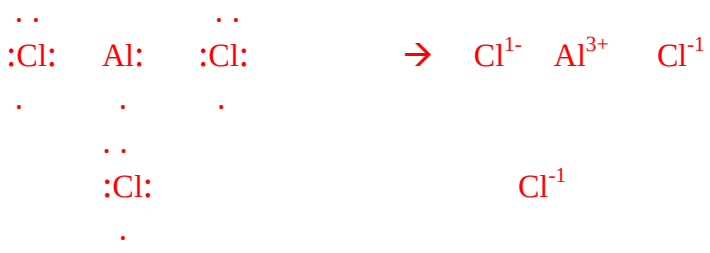
(13 p^+) + (13 e^-) = 0

(13 p^+) + (10 e^-) = 3+

d) Write the chemical formula of aluminum chloride. Explain the ratio in which aluminum and chlorine atoms form a chemical compound.

$AlCl_3$

When one Al atom and three Chlorine atoms are brought together, the nuclei of Cl attract loosely attached valence electrons of Al, fulfilling octets. The number of protons and electrons in each atom are not equal anymore, so ions form:



e) Draw the Bohr model for the chloride ION and determine the charge on the chloride ion. Show the number of protons and electrons and show where they are found in the ion.

Cl^{1-} $17\ p^+$)2e)8e)8e

f) Write a procedure in a numbered list for how you would make 300ml of a 7% (mass/volume) aluminum chloride solution. Show all calculations.

7% = 7 grams $AlCl_3$/100 ml of solution
300 ml of solution
Grams of $AlCl_3$ - ?

$$300\ ml\ solution \times \frac{7\ grams\ AlCl_3}{100\ ml\ solution} = 21\ gram\ rounded\ to\ 1\ sig\ fig\ 20\ g$$

1. Place on a scale empty weighing dish, zero it out
2. Add 20 g of solid $AlCl_3$
3. Transfer to 300 ml volumetric flask using funnel
4. Rinse weighing dish and funnel with DI water and pour residue into volumetric flask with aluminum chloride
5. Add slowly DI water to volumetric flask up to the line

g) If you have already prepared this 7% (mass/volume) aluminum chloride solution, how could you dilute it to make 0.5 L of a 2% solution? Show your work.

$$C_1V_1 = C_2V_2 \rightarrow V_1 = \frac{C_2V_2}{C_1} = \frac{2\% \times 0.5L}{7\%} = 0.1\ L$$

$C_1 = 7\%$
$C_2 = 2\%$
$V_1 = ?$
$V_2 = 0.5\ L$

h) Write an experimental procedure in a numbered list form for this dilution.

1. Measure 100 ml of 7% solution with graduated cylinder
2. Place it in a 1 liter beaker
3. Measure out 400 ml of DI water and add to the same beaker
4. Mix it.

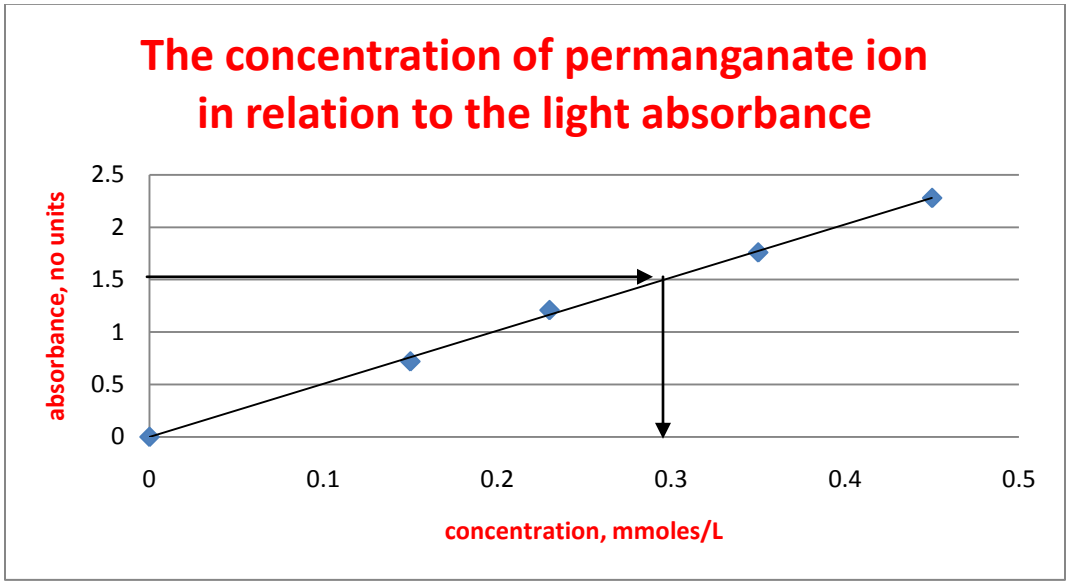
i) Which solution of aluminum chloride is more concentrated 7% or 7M? Explain your reasoning and show all calculations. *7M solution is more concentrated*

$$7\% = \frac{7g\ AlCl_3}{100\ ml\ solution} \times \frac{1\ mol\ AlCl_3}{133.5\ g} \times \frac{1000\ ml}{1L} = 0.5M\ solution\ of\ AlCl_3$$

3. A solution of the permanganate ion is purple. Because of this, the concentration of permanganate ion is often determined by measuring its absorbance of light. The absorbance data below were determined for known concentrations of permanganate ion.

Concentration (mmoles/L)	Absorbance (no units)
0.00	0.00
0.15	0.72
0.23	1.21
0.35	1.76
0.45	2.28

a) Using the above information, make a graph representing this data. Draw a line or curve of best fit.



b) Make observations and draw a generalization about the relationship between the absorbance and concentration. Is this relationship linear or nonlinear? Is this relationship direct or inverse?

As the concentration of permanganate ion increases, so as absorbance of light. It is a direct relationship because both variables increase in conjunction. It appears to be linear relationship, but we need equation for the slope to confirm it.

c) Using your line of best fit; create a prediction for concentration of permanganate ion in a solution whose absorbance is 1.50. Use the graph to support your prediction.

0.3 mmoles/L

4. The density of carbon in the form of diamond is 3.52 g/cm^3. Graphite is another modification (allotrope) of carbon and it has density of 2.67 g/cm^3. What does it tell you about the arrangement of carbon atoms in diamond vs graphite?

Since density describes how tightly particles that make up a substance, in this case atoms of carbon, are packed, then higher density shows that atoms are packed closer together resulting in a higher mass per volume ratio. Diamond has more atoms per unit of volume than graphite does. Graphite atoms have more space in between each other.

If you take 5 mg samples of each carbon allotrope, which one would have higher volume? Create a hypothesis about which allotrope of carbon has higher volume and then test your hypothesis using mathematical calculations and reasoning. Show all your work.

Hypothesis: 5 mg of diamond will occupy smaller volume than 5 mg of graphite

For diamond: $5\ mg \times \frac{1g}{1000\ mg} \times \frac{1\ cm^3}{3.52\ g} = 0.0014\ cm^3$

For graphite: $5\ mg \times \frac{1g}{1000\ mg} \times \frac{1\ cm^3}{2.67\ g} = 0.0019\ cm^3$

5. Large quantities of fertilizer are washed into the Mississippi River from agricultural land in the midwest. The excess nutrients collect in the Gulf of Mexico, promoting the growth of algae and endangering other aquatic life. One commonly used fertilizer is ammonium nitrate, NH_4NO_3. Corn farmers typically use 5.0 x 10^3 kg of ammonium nitrate per square kilometer of cornfield per year. Ammonium Nitrate can be prepared by the following reaction:

NH_3	+	HNO_3 →	NH_4NO_3
ammonia		nitric acid	ammonium nitrate

a) How many grams of ammonium nitrate per square kilometer are used by corn farmers in a year? Show all calculations.

$$\frac{5.0 \times 10^3\ kg}{1\ km^2 \times yr} \times \frac{1000\ g}{1\ kg} = \frac{5.0 \times 10^6\ g}{1\ km^2 \times yr}$$

b) How many moles of ammonium nitrate per square kilometer are used in a year? Show all calculations, units, significant figures, scientific notation if applicable, and units' cancellation.

$$\frac{5.0 \times 10^6\ g}{1\ km^2 \times yr} \times \frac{1\ mole\ NH_4NO_3}{80\ g} = \frac{6.3 \times 10^4\ moles\ NH_4NO_3}{1\ km^2 \times yr}$$

c) Using the moles of ammonium nitrate used in a year and balanced equation; find how many moles of nitric acid are used for production of ammonium nitrate? Show all calculations, units, significant figures, scientific notation if applicable, and units' cancellation.

$$\frac{6.3 \times 10^4 \text{ moles } NH_4NO_3}{1 \text{ km}^2 \times \text{yr}} \times \frac{1 \text{ mole } HNO_3}{1 \text{ mole } NH_4NO_3} = \frac{6.3 \times 10^4 \text{ moles } HNO_3}{1 \text{ km}^2 \times \text{yr}}$$

d) How many kilograms of nitric acid would be required to make the fertilizer needed for $1 km^2$ of cornfield per year? Show all calculations, units, significant figures, scientific notation if applicable, and units' cancellation.

$$\frac{6.3 \times 10^4 \text{ moles } HNO_3}{1 \text{ km}^2 \times \text{yr}} \times \frac{63 \text{ g}}{1 \text{ mole } HNO_3} \times \frac{1 \text{ kg}}{1000 \text{ g}} = \frac{4.0 \times 10^3 \text{ kg}}{1 \text{ km}^2 \times \text{yr}}$$