CHEMISTRY 504 Review Questions (January 2020) Name: Answer Key.

1. Sarah was studying the reaction between magnesium, Mg, and hydrochloric acid, HCl. This reaction produces hydrogen gas, H_2, and magnesium chloride, $MgCl_2$, as shown by the chemical equation below.

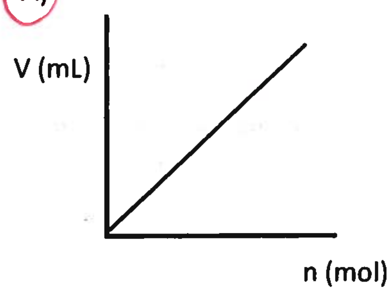
$$Mg_{(s)} + 2\,HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$$

Keeping pressure and temperature constant, Sarah performed three trails for this reaction. For each trial she reacted a different concentration of hydrochloric acid with a surplus of magnesium powder.

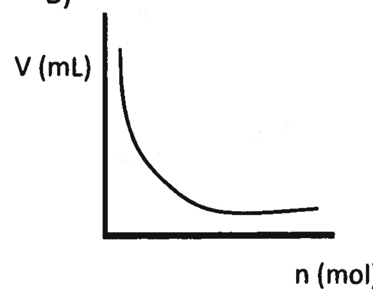
Sarah recorded the volume of the H_2 gas collected for each trial.

Which of the following graphs represents the relationship between the variables for this experiment?

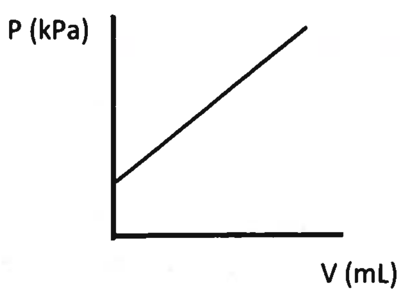
A)



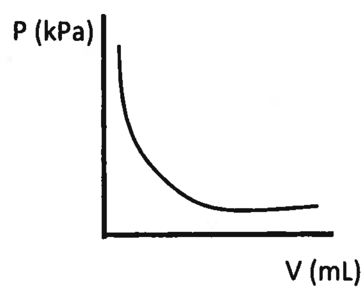
B)



C)



D)



2. A can of shaving cream is heated in boiling water. A second can of shaving cream is chilled in a bath of ice water. When the cans are aimed and squirted, the shaving cream in the hot can travels much further than the shaving cream in the cold can as illustrated in the diagram below.

   Using the kinetic molecular theory, which statement below best describes why the shaving cream in the heated can travelled further than the shaving cream in the cold can?

   A) At any given temperature the molecules of all gases have the same average kinetic energy.
   B) The volume of all of the molecules of the has is negligible when compared to the total colume in which the gas is contained.
   C) Molecules can collide with each other with no loss of kinetic energy; the collisions are perfectly elastic.
   D) The average kinetic energy of the molecules is proportional to the temperature of the gas.

3. When a 50.0 g piece of nickel absorbs 350.0 J of heat, the temperature of the nickel changes from 20.0°C to 36.0°C. What is the specific heat capacity of nickel?

   A) 1.10 J/ g °C
   B) 4.15 J/ g °C
   C) 2.24 J/ g °C
   D) 0.437 J/ g °C

$Q = mc\Delta T$

$350.0\,J = (50.0\,g)(c)(36.0 - 20.0)$

$c = 0.437 \frac{J}{g\,°C}$

4. While traveling, an airplane passenger placed a bag of potato chips in his checked luggage. When he opened the luggage, the bag had exploded and potato chips were everywhere in his luggage. Which gas law is this an example of?

   A) Avogadro's Law
   B) Ideal Gas Law
   C) Charles's Law
   D) Boyle's Law

5. A gas is heated to 80. °C and a pressure of 180 kPa. If the container expands to hold a volume of 800. mL, what was the volume of the gas, (in litres), at a temperature of 50. °C and 120 kPa pressure?

A) 1.9×10^3 L
B) 7.5×10^2 L
C) 1.1×10^2 L
D) 1.1×10^0 L

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{(120\,kPa)V_1}{(323K)} = \frac{(180kPa)(0.8L)}{(353K)}$$

$$V_1 = 1.1L$$

6. A diver is sitting at the bottom of a pool. She opens her mouth and releases a bubble of air that rises up to the surface. The pressure at the bottom of the pool is 291 kPa. At the surface, the pressure is 101 kPa. Just as the bubble breaks the surface it has a volume of 745 mL.

What was the volume of the air bubble at the bottom of the pool?

$$P_1V_1 = P_2V_2$$

$$(291kPa)V_1 = (101kPa)(745mL)$$

$$\cancel{258.6mL} = V_1$$

$$258.6mL = V_1$$

7. Liquid vegetable oil can be converted into solids (like margarine) by a process called hydrogenation. Such a reaction can be seen below:

$$\underset{\text{Olein}}{(C_{17}H_{33}COO)_3C_3H_{5(l)}} + 3\ H_{2(g)} \rightarrow \underset{\text{Stearin}}{(C_{17}H_{35}COO)_3C_3H_{5(s)}}$$

Assume that 3.00×10^3 L of hydrogen gas at 25.0°C and 101.3 kPa is consumed in the reaction. Calculate the amount of Stearin, in grams, produced based on the amount of hydrogen gas collected.

1 $MM_{stearin} = 891.48 g/mol$

$$PV = nRT$$

$$(101.3 kPa)(3.00 \times 10^3 L) = n\left(8.31 \frac{kPa L}{mol \cdot K}\right)(298 K)$$

$$122.72 \text{ mol} = n_{H_2}$$

2
$$\frac{1 \text{ mol Stearin}}{3 \text{ mol } H_2} = \frac{n}{122.72 \text{ mol } H_2}$$

$$n = 40.9 \text{ mol}$$

3
$$\frac{891.48 g}{1 \text{ mol}} = \frac{'m'}{40.9 \text{ mol}}$$

$$'m' = 3.65 \times 10^4 g \text{ Stearin}$$

8. A science teacher has filled a balloon with a gas that is denser than air.

The teacher tells the class that the gas in the balloon is probably sulfur hexafluoride, SF_6, but she is not entirely sure. The following data was collected.

Data Table

Volume of balloon	0.10 L
Pressure in balloon	110 kPa
Temperature	20.0 °C
Mass of empty balloon	1.31 g
Mass of balloon with dense gas	1.97 g

Taking experimental error into account, could the gas in the balloon be SF_6?

$$PV = nRT$$

$$(110\,kPa)(0.10\,L) = n\left(8.31\,\frac{kPa \cdot L}{mol \cdot K}\right)(293.2\,K)$$

$$4.51 \times 10^{-3}\,mol = n$$

$$\Delta m = 1.97 - 1.31\,g$$

$$= 0.66\,g$$

$$MM_{gas} = \frac{0.66\,g}{4.51 \times 10^{-3}\,mol} = 146.2\,g/mol$$

$$MM_{SF_6} = 146.05\,g/mol$$

Yes it could be SF_6

9. Assuming ideal behaviour, which of the gas samples presented below has the greatest volume at STP? Provide a justification for your answer.

(a) 1 g of H_2 (b) 1 g of O_2 (c) 1 g of Ar

$\frac{2.02\,g\,H_2}{1\,mol} = \frac{1\,g\,H_2}{X\,mol}$ $\frac{32.00\,g\,O_2}{1\,mol} = \frac{1\,g\,O_2}{X\,mol}$ $\frac{39.95\,g\,Ar}{1\,mol\,Ar} = \frac{1\,g\,Ar}{X\,mol\,Ar}$

$\boxed{X = 0.495\,mol\,H_2}$ $X = 0.03125\,mol\,O_2$ $X = 0.0250\,mol\,Ar$

Justification: At STP, under identical conditions for each gas, the gas that has the greatest number of moles will occupy the greatest volume

10. A 31.1 g wafer of pure gold, initially at 69.3 °C, is submerged into 64.2 g of water at 27.8°C in an insulated container. What is the final temperature of both substances at thermal equilibrium? (Specific heat capacity of gold is 0.129 J/g°C, specific heat capacity of water is 4.19 J/g°C)

$$-Q_{HOT} = +Q_{COLD}$$

$$-mC\Delta T = mC\Delta T$$

$$-(31.1g)(0.129\tfrac{J}{g°C})(T_F - 69.3) = (64.2g)(4.19\tfrac{J}{g°C})(T_F - 27.8°C)$$

$$4.0119(T_F - 69.3) = 268.998(T_F - 27.8)$$

$$4.0119\,T_F - 278.02 = 268.998\,T_F - 7478.14$$

$$7200.11 = 264.986\,T_F$$

$$\boxed{27.2°C = T_F}$$

11. A company manufactures a gas mixture of argon, Ar and hydrogen, H_2, for use during the welding process. The argon-hydrogen mixture is sold in 50.0 L cylinders.

The mixture is prepared by injecting hydrogen gas into a 50.0 L cylinder containing pure argon gas at a pressure of 1.35×10^4 kPa at 15.0 °C until the pressure of 1.50×10^4 kPa is reached. The temperature remains constant.

The hydrogen for the mixture is produced by the electrolysis of water, as shown by the chemical equation below:

$$2\,H_2O_{(l)} \rightarrow O_{2(g)} + 2\,H_{2(g)}$$

What is the minimum mass of water required to produce enough hydrogen for one cylinder of the gas mixture? (Assume no gas is lost.)

$1.50 \times 10^4\ \text{kPa} - 1.35 \times 10^4\ \text{kPa} = 1.5 \times 10^3\ \text{kPa}$

$PV = nRT$

$(1.5 \times 10^3\ \text{kPa})(50.0\ \text{L}) = n(8.31)(288\ \text{K})$

$\underset{\text{mol } H_2}{31.34} = n$

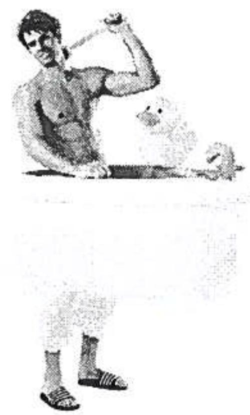
$$31.34\ \text{mol } H_2 \left(\frac{2\ \text{mol } H_2O}{2\ \text{mol } H_2}\right)\left(\frac{18.02\ \text{g } H_2O}{1\ \text{mol } H_2O}\right)$$

$= 564.7\ \text{g } H_2O$

12. Phileas Fogg, the character who went around the world in 80 days, was very fussy about his bathwater temperature. It had to be exactly 38.0° C.

You are his butler, and one morning while checking his bath temperature, you notice that it is 42.0°C. You plan to cool the 100.0 kg of water to the desired temperature by adding an aluminum-duckie originally at freezer temperature (-24.0°C).

Of what mass should the Al-duckie be? [Specific heat of Al = 0.900 J/(g°C); density of water =1 .00 g/ml]. Assume that no heat is lost to the air.



Water

$T_f = 38.0^\circ C$

$T_i = 42.0^\circ C$

$m = 100{,}000\,g$

$c = 4.19 \frac{J}{g^\circ C}$

Al duckie

$T_f = 38.0^\circ C$

$T_i = -24.0^\circ C$

$m = ?$

$c = 0.900 \frac{J}{g^\circ C}$

$$-Q_{HOT} = +Q_{COLD}$$

$$-(100{,}000\,g)(4.19)(38.0^\circ C - 42.0) = (m)\left(0.900 \frac{J}{g^\circ C}\right)(38.0 - -24.0^\circ C)$$

$$\frac{1.676 \times 10^6}{55.8} = \frac{m(55.8)}{55.8}$$

$$3.00 \times 10^4\,g = m$$

or

30.0 kg

13. The list below shows the assumptions made by the kinetic molecular theory. Determine whether each statement is true or false. If false, make correction to the statement in question. Justify each statement with and explanation.

Gas molecules are in constant, random motion, moving through vibrational and rotational motions.

True / False

+ translational

The kinetic energy of gas molecules is ~~inversely~~ proportional to their temperature in Kelvins. That is to say that as temperature increases, their kinetic energies ~~decrease.~~ increases

True / False

Gas molecules have an infinitely small volume.

True / False

Gas molecules interact with one another through attraction and repulsion.

True / False

No interaction