**Worksheet 13: Kinetic Theory and the Ideal Gas Law**

**Objective A: Kinetic Theory**

**Questions:**

1. What does kinetic theory say about the motion of atoms, and temperature?
2. Why do some objects expand when heated? Why is Pyrex glass designed not to expand?

**Objective B: Temperature Scales**

**Questions:**

1. What is the meaning of 0 K, 0 oC, and 0 oF?
2. Which scale MUST YOU USE in the ideal gas law?

**Problems:**

1. What is 23.00 oC in Kelvins? (296.15 K)
2. What is 452.00 K in oC? (178.85 oC)
3. What is 27.0 oF in oC? (-2.78 oC)
4. What is 37.0 oC in oF? (98.6 oF)
5. What temperature is the same in oC and oF? (If you already know, prove it) (-40)

**Objective C: P = F/A**

**Questions:**

1. What is pressure, and what causes it?
2. Why do high heels dent cedar decks? How do snowshoes work?

**Problems:**

1. A force of 23,450 N is exerted on a rectangular window that measures 2.30 m by 0.980 m. What is the pressure? (1.04E4 Pa)
2. What is the force of 2100. psi over a circular flange with a radius of 8.5 inches? (476658 lbs ≈ 4.8E5 lbs)
3. What is the total area in m2 of some snowshoes, if a 75 kg person does not exert a pressure greater than 1.2 x 103 Pa? (0.61 m2)

**Objective D: Converting units of pressure. 1.00 atm = 1.013 x 105 Pa = 101.3 kPa = 760. Torr = 14.7 psi**

1. Convert 450. Torr to Pa. (6.00E4 Pa)
2. Convert 35 psi to Pa. (2.4E5 Pa)
3. Convert 3.20 ATM to Pa. (3.24E5 Pa)
4. Convert 16.7 kPa to Pa. (1.67E4 Pa)
5. Convert 835 Torr to psi (16.2 psi)
6. Convert 2350 Pa to psi (0.341 psi)

**Objective E: Gauge Pressure. P = PG + 1 atm**

**Questions:**

1. What is the difference between gauge and absolute pressure?
2. Which pressure MUST YOU USE in the ideal gas law, absolute or gauge?

**Problems:**

1. What is 0.45 atm gauge in absolute pressure? (1.45 atm)
2. What is 3.60 atm absolute in gauge pressure? (2.60 atm)
3. What is 34.0 psi gauge in absolute pressure? (48.7 psi)
4. What is 45.0 psi absolute in gauge pressure (30.3 psi)
5. What is 4.5 psi absolute in gauge pressure? (-10.2 psi)
6. What is 34,500 Pa gauge in absolute pressure? (1.358E5 Pa)
7. What is 3.415 x 105 Pa in absolute in gauge pressure? (2.402E5 Pa)

**Objective F: Ideal Gas Law: PV = nRT, R = 8.31 J/(mol K)**

Some molar masses:

H 1.0079

He 4.003

N 14.0067

Br 79.904

Xe 131.293

1. What is the volume of one mol of an ideal gas at standard temperature and pressure (STP)? (P = 1.000 atm = 1.013x105 Pa, T = 0oC = 273.15 K) What is the volume in liters? (1 m3 = 1000 liters) (22.4 liters)
2. George Uss has 0.34 mols of Xenon tetrafluoride in a container with a volume of 0.159 m3 at 78.0 oC. What is the **pressure**? (6.2E3 Pa)
3. Hugh Jass has a volume of 143 liters and 2.56 mols of Xenon gas at a pressure of 67,120 Pa. What must be the **temperature** in Kelvins? What is the temperature in oC (451 K, 178 oC)
4. Anita Breke fills a large helium balloon with 2.18 grams of Helium gas. How many mols of He is this? What is the pressure in the balloon if the gas occupies a volume of 12.05 liters (1000 liters = 1 m3) at a temperature of 18.0 oC? (Beware the ides of Celsius!) What is that pressure in atmospheres? What is the gauge pressure in Pa and Atmospheres? (0.545 mols,1.09 x 105 Pa, 1.08 atm, 8 x103 Pa, .08 atm)
5. A reaction vessel operates at 3.14 atmospheres. What is that pressure in Pa? If the vessel has a volume of 0.113 m3, is at a temperature of 145 oC, and contains pure Nitrogen gas, how many mols of nitrogen gas does it contain? How many grams of Nitrogen does it contain? (None Of Fred’s Clients Bring Iron Hats – Nitrogen is a diatomic gas) (3.18x105 Pa, 10.3 mols, 290. g)
6. A container has a volume of 216 liters. (1000 liters = 1 m3) If it can sustain a pressure of 13.5 atmospheres before bursting, and contains 89.1 grams of Hydrogen gas, a) what is its bursting pressure in Pa? b) how many mols of Hydrogen does it contain? and c) what is its maximum operating temperature in K and oC? (1.37x106 Pa, 44.2 mols, 804 K, 531 oC)
7. A 2.00 liter bottle contains 18.15 grams of Bromine gas and is at a gauge pressure of 0.153 atm. What is its temperature in Celsius? (-26 oC)
8. George has 205 grams of Hydrogen gas at 1275 Torr Gauge pressure and 127.0 oC. What must be the **volume** of the container? (1.25 m3)
9. Jeanne has 1,529 grams of Xenon gas in 127 liters at a temperature of –16.0 oC. What must be the **gauge pressure in psi**? (13.7 psi gauge)

**Objective G: Combined Gas Law:** ****

1. An aerosol can is at an absolute pressure of 603 Boogalas when it is at 312 K. If I put it in liquid nitrogen and lower its temperature to 77.0 K, what is the new **pressure** in Boogalas? (1000 milli Boogalas = 1 Boogala) (Assume it does not leak, and the volume remains constant) (149 Boogalas)
2. Air trapped in an airtight cylinder when the piston is 34.1 inches high is at 57.0 Jukkulas. How **high** must the piston be if the pressure is later at a pressure of 115 Jukkulas? Assume temperature remains constant. (16.9 inches)
3. A Tupperware container is at 1.00 atm at 21.0 oC. (Convert to K) It is heated in a microwave to 99.5 oC with the lid on. Assuming no gas escapes, what is the pressure inside in atm? (1.27 atm)
4. A quantity of ideal gas is compressed at constant temperature from 34.5 liters to 12.4 liters. What was the initial pressure if the final pressure was 2.45x105 Pa? (8.81x104 Pa)
5. A balloon has a volume of 1.25 liters at 20.5 oC. At what temperature does it have a volume of 1.02 liters, assuming the pressure and mols remain constant? (-33.5 oC)
6. One mol of an ideal gas occupies 22.4 liters at STP. (P = 1.000 atm T = 0.00oC) What volume does it occupy at 97.0 oC and 1.29 atm? (23.5 liters)
7. My car tire has a gauge pressure of 32.0 PSI when the temperature is 23.0 oC, what is the temperature in Celsius if the gauge pressure is later 48.0 PSI? (Assume that the tire does not leak, and that the volume remains constant) (124 oC)
8. A container with a volume of 3.7 bushels is at a **gauge** pressure of 274 kPa and 57.0 oC. If it does not leak, and later the **gauge** pressure is 117 kPa at 145 oC, what is the new **volume** of the container? (8.06 bushels)
9. An airtight container has a sliding wall, so its volume can change. When the volume is 13.7 cc, the **gauge** pressure is 0.150 ATM and the temperature is 25.0 oF. What must be the new **gauge pressure** if the container has a volume of 42.1 cc at 450. oF? (Absolute zero is -459.67 oF) (-0.298 atm)
10. A steel nitrogen tank has a mass of 5.36 kg. When it is at 68.0 oF, and 742 psi gauge, it has a mass of 9.83 kg because of the added nitrogen gas. If the gauge pressure is 347 psi, and the mass of the tank is 7.15 kg because some nitrogen was released, what must be the temperature? (170. oF)

**Objective H:**

**Questions:**

1. When does the ideal gas law not work, and why does it not work?
2. Why is there almost no atmospheric helium and hydrogen?