KCS @ home

Summer Edition

Chemistry

Activity 3
knoxschools.org/kcsathome

Activity 3: Student Handout

Characteristics of Gases

Peep Video Reflection

- What was the independent variable in the peep experiment?
- What was the dependent variable in the peep experiment?
- Write a sentence about their relationship.

Boyle's Law

- Formula:
- Practice: A balloon filled with helium gas has a volume of 500 mL at a pressure of 1 atm. The balloon is released and reaches an altitude of 6.5 km, where the pressure is 0.5 atm. Assuming that the temperatures remain the same, what volume does the gas occupy at this height?
    - Variables given:
    - Solve for:
    - Math:

Balloon Video Reflection

- What was the independent variable in the balloon experiment?
- What was the dependent variable in the balloon experiment?
- Write a sentence about their relationship.

Charles's Law

- Formula:
- Practice: A aerosol can is kept at 25°C occupies 0.50 L. Directions on the can warn the user not to keep the can in a place where the temperature exceeds 52°C. If the temperature is increases to 52°C, what will the volume be, assuming the same pressure?
    - Variables given:
    - Solve for:
    - Math:

Gay-Lussac's Law

- Formula
- Practice: The gas in an oxygen tank is at a pressure of 3.00 atm at 25°C. What would the gas pressure in the can be at 52°C?
  - Variables given:
  - Solve for:
  - Math:

<u>Russian Tanker Video Reflection</u>

- What factors lead to the tanker's collapse?
- Write a sentence about their relationship.

The Combined Gas Law

- Formula
- Practice: A helium-filled balloon has a volume of 50 L at 25°C and 1.08 atm. What volume will it have at STP?
  - Variables given:
  - Solve for:
  - Math:

Practice #1

1. A gas has a temperature of 14°C, and a volume of 4.5 liters. If the temperature is raised to 29°C and the pressure is constant, which means it is not changed, what is the new volume of the gas?

2. A gas that has a volume of 28 liters, a temperature of 45°C, and a pressure of 2.0 atm. What volume will it occupy at STP?

3. If I have 17 liters of gas at a temperature of 67 ^{0}C and a pressure of 89 atm, what will be the pressure of the gas if I raise the temperature to 94 ^{0}C and decrease the volume to 2000. mL?

4. If I have 2.9 L of gas at a pressure of 5.0 atm and a temperature of 50.0°C, what will be the temperature of the gas if I decrease the volume of the gas to 2.4 L and decrease the pressure to 3.0 atm?

5. Congratulations! You just won an all-expenses paid Carribbean vacation. As apart of your package, you get to go SCUBA diving in the clear waters. At sea level the air pressure is 1 atm, but as a diver descends to 66 feet, the pressure increases to 3 atm. Nitrogen gas enters your bloodstream as you descend, and if you ascend back to surface slowly, the nitrogen is released unnoticed. However, if you ascend quickly, the nitrogen gas forms bubbles in your blood. What volume would a 2 mL sized nitrogen bubble at -66 ft become once you ascended back to sea level?

Winter Tire Maintenance Video Reflection

- What factors affect tire pressure when the winter comes?

- Write a sentence about their relationship.

The Ideal Gas Law

- Formula
  - P
  - V
  - n
  - R
  - T

- Practice: What is the pressure in atmospheres exerted by a 0.500 mol sample of nitrogen gas in a 10.0 L container at 298 K?
  - Variables given:
  - Solve for:
  - Math:

- Practice: At what Celsius temperature does a 54 mL tank at 745 torr that contains a 0.62 gram sample of nitrogen gas?
  - Variables given:
  - Solve for:

- Convert:

- Math:

- Practice: What mass of chlorine, Cl_2, in grams, is contained in a 10.0 L tank at 27°C and 200 kPa of pressure?
  - Variables given:
  - Solve for:
  - Math:

Practice

1. If I have 4.0 moles of a gas at a pressure of 5.6 atm and a volume of 12 liters, what is the temperature?

2. If I have an unknown quantity of gas at a pressure of 121.56 kPa, a volume of 31 liters, and a temperature of 87°C, how many moles of gas do I have?

3. If I contain 0.153 moles of gas in a container with a volume of 926 mL and at a temperature of 32°C, what is the pressure inside the container in kPa?

4. If I have an unknown quantity of argon gas at a pressure of 0.50 atm, a volume of 25 liters, and a temperature of 300.0 K, how many grams of gas do I have?

5. If I have 17 grams of carbon dioxide gas at a pressure of 743 mmHg in a container of 12.1 L, what is the temperature of the gas?

Chemistry Reference Sheet

Periodic Table of the Elements

Key

11 — Atomic Number **Na** — Element Symbol Sodium — Element Name 22.990 — Average Atomic Mass *

Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 **H** Hydrogen 1.008																	2 **He** Helium 4.003
2	3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012											5 **B** Boron 10.811	6 **C** Carbon 12.011	7 **N** Nitrogen 14.007	8 **O** Oxygen 15.999	9 **F** Fluorine 18.998	10 **Ne** Neon 20.180
3	11 **Na** Sodium 22.990	12 **Mg** Magnesium 24.305											13 **Al** Aluminum 26.982	14 **Si** Silicon 28.086	15 **P** Phosphorus 30.974	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.453	18 **Ar** Argon 39.948
4	19 **K** Potassium 39.098	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.956	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.942	24 **Cr** Chromium 51.996	25 **Mn** Manganese 54.938	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933	28 **Ni** Nickel 58.693	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.409	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.610	33 **As** Arsenic 74.922	34 **Se** Selenium 78.960	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.800
5	37 **Rb** Rubidium 85.468	38 **Sr** Strontium 87.620	39 **Y** Yttrium 88.906	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.906	42 **Mo** Molybdenum 95.940	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.070	45 **Rh** Rhodium 102.906	46 **Pd** Palladium 106.420	47 **Ag** Silver 107.868	48 **Cd** Cadmium 112.411	49 **In** Indium 114.818	50 **Sn** Tin 118.710	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.600	53 **I** Iodine 126.904	54 **Xe** Xenon 131.290
6	55 **Cs** Cesium 132.905	56 **Ba** Barium 137.327	57 **La** Lanthanum 138.905	72 **Hf** Hafnium 178.490	73 **Ta** Tantalum 180.948	74 **W** Tungsten 183.840	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.230	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.084	79 **Au** Gold 196.967	80 **Hg** Mercury 200.590	81 **Tl** Thallium 204.383	82 **Pb** Lead 207.200	83 **Bi** Bismuth 208.980	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
7	87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (266)	107 **Bh** Bohrium (264)	108 **Hs** Hassium (269)	109 **Mt** Meitnerium (268)	110 **Ds** Darmstadtium (271)	111 **Rg** Roentgenium (272)	112 **Cn** Copernicium (285)	113 **Uut** ?	114 **Fl** Flerovium (289)	115 **Uup** ?	116 **Lv** Livermorium (292)	117 **Uus** ?	118 **Uuo** ?

58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.908	60 **Nd** Neodymium 144.242	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.360	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.250	65 **Tb** Terbium 158.925	66 **Dy** Dysprosium 162.500	67 **Ho** Holmium 164.930	68 **Er** Erbium 167.259	69 **Tm** Thulium 168.934	70 **Yb** Ytterbium 173.040	71 **Lu** Lutetium 174.967
90 **Th** Thorium 232.038	91 **Pa** Protactinium 231.036	92 **U** Uranium 238.029	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (262)

* If this number is in parentheses, then it refers to the atomic mass of the most stable isotope.

Turn over for Formulas, Constants, and Unit Conversions

Knox County Science
Chemistry 1 Reference Sheet

Formulas

Specific Heat Capacity: $q = mC_p\Delta T$

Heat of fusion: $q = m\Delta H_{fus}$

Heat of vaporization: $q = m\Delta H_{vap}$

Ideal Gas Law: $PV = nRT$

Molarity (M): $M = \frac{moles\ of\ solute}{Liters\ of\ solution}$

Molaltiy(m): $m = \frac{moles\ of\ solute}{kg\ of\ solvent}$

$M_1V_1 = M_2V_2$

Combined Gas Law: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$P_{gas} = (P_{total})X_{gas}$

$c = \lambda\upsilon$ $E = h\upsilon$

$\frac{rate1}{rate2} = \sqrt{\frac{MM2}{MM1}}$

$pH + pOH = 14$

$pH = -\log[H_3O^+]$

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

$K_w = [H_3O^+][OH^-] = 1.0x10^{-14}$

Boiling point elevation: $\Delta T_b = k_b\, m\, i$

Freezing point depression: $\Delta T_f = k_f\, m\, i$

Constants

Speed of light (c) = 3.00×10^8 m/s

Planck's constant (h) = 6.626×10^{-34} Js

Molar Volume = 22.4 $\frac{L}{mol}$ @ STP

Universal Gas Constant (R): 0.0821 $\frac{L*atm}{mol*K}$ - OR - 8.31 $\frac{L*kPa}{mol*K}$

Avogadro's number: 1 mole = 6.02×10^{23} molecules or formula units

Specific Heat Capacity of liquid Water: C_p (H_2O) = 1.00 $\frac{cal}{g*°C}$ - OR - 4.18 $\frac{J}{g*°C}$

Molal freezing point of water: k_f = 1.86°C/m

Molal boiling point of water: k_b = 0.521°C/m

Unit Conversions

1 atm = 760 mm Hg = 760 torr = 101.3 kPa = 14.7 psi

K = °C + 273

1.000 calorie = 4.184 Joules

1 mL = 1 cm^3

1L = 1,000 mL = 1,000 cm^3

tera (T) = 10^{12}, giga (G) = 10^9, mega (M) = 10^6, kilo (k) = 10^3, hecto (h) = 10^2, deka (da) = 10^1
deci (d) = 10^{-1}, centi (c) = 10^{-2}, milli (m) = 10^{-3}, micro (μ) = 10^{-6}, nano(n) = 10^{-9}, pico (p) = 10^{-12}

Common Ions

Element Name	Charges	Polyatomic Ions	Charges	Polyatomic Ions	Charges
Silver (Ag^{1+})	1+	Ammonium (NH_4^+)	1+	Sulfate (SO_4^{2-})	2-
Zinc (Zn^{2+})	2+	Hydronium (H_3O^+)	1+	Sulfite (SO_3^{2-})	2-
Scandium (Sc^{3+})	3+	Nitrate (NO_3^-)	1-	Carbonate (CO_3^{2-})	2-
Copper (Cu^{1+}, Cu^{2+})	1+, 2+	Nitrite (NO_2^-)	1-	Peroxide (O_2^{2-})	2-
Gold (Au^{1+}, Au^{3+})	1+, 3+	Hydrogen Carbonate (HCO_3^-)	1-	Chromate (CrO_4^{2-})	2-
Cobalt (Co^{2+}, Co^{3+})	2+, 3+	Perchlorate (ClO_4^-)	1-	Dichromate ($Cr_2O_7^{2-}$)	2-
Nickel (Ni^{2+}, Ni^{3+})	2+, 3+	Chlorate (ClO_3^-)	1-	Oxalate ($C_2O_4^{2-}$)	2-
Lead (Pb^{2+}, Pb^{4+})	2+, 4+	Chlorite (ClO_2^-)	1-	Silicate (SiO_3^{2-})	2-
Tin (Sn^{2+}, Sn^{4+})	2+, 4+	Hypochlorite (ClO^-)	1-		
Mercury (Hg_2^{2+}, Hg^{2+})	1+, 2+	Bromate (BrO_3^-)	1-		
Iron (Fe^{2+}, Fe^{3+})	2+, 3+	Iodate (IO_3^-)	1-	Phosphate (PO_4^{3-})	3-
Titanium (Ti^{2+}, Ti^{3+}, Ti^{4+})	2+, 3+, 4+	Hydroxide (OH^-)	1-	Phosphite (PO_3^{3-})	3-
Chromium (Cr^{2+}, Cr^{3+})	2+, 3+	Acetate ($C_2H_3O_2^-$ or CH_3COO^-)	1-	Borate (BO_3^{3-})	3-
Vanadium (V^{2+}, V^{3+}, V^{4+})	2+, 3+, 4+	Permanganate (MnO_4^-)	1-		
Manganese (Mn^{2+}, Mn^{3+}, Mn^{4+})	2+, 3+, 4+	Cyanide (CN^-)	1-		

Chemistry Activity 3: Answer Key

Combined Gas Law Practice

1. 4.7 L
2. 48 L
3. 817 atm
4. 160 K or -113 °C
5. 6 mL

Ideal Gas Law Practice

1. 204 K or -68 °C
2. 1.26 mol
3. 418 kPa
4. 20 g Ar
5. 373 K or 100 °C

Chemistry Activity 3: Solutions

Combined Gas Law Practice

1. Given:
   - T_1 = 14°C + 273 = 287 K
   - V_1 = 4.5 L
   - T_2 = 29°C + 273 = 302 K
   - V_2 = ?

$$\frac{V1}{T1} = \frac{V2}{T2} \qquad \frac{4.5\ L}{287\ K} = \frac{V2}{302\ K}$$

$$(302\ K)\frac{4.5\ L}{287\ K} = \frac{V2}{302\ K}(302\ K)$$

V_2 = 4.7 L

2. Given:
   - V_1 = 28 L
   - T_1 = 45°C + 273 = 318 K
   - P_1 = 2.0 atm
   - V_2 = ?
   - P_2= 1.0 atm
   - T_2 = 0°C + 273 = 273 K

$$\frac{P1V1}{T1} = \frac{P2V2}{T2} \qquad \frac{2\ x\ 28}{318} = \frac{1\ x\ V2}{273}$$

$$(273)\ \frac{56}{318} = \frac{1\ x\ V2}{273}\ (273)$$

V_2 = 48 L

3. Given:
   - V_1 = 17 L
   - T_1 = 67°C + 273 = 340 K
   - P_1 = 89 atm
   - P_2 = ?
   - T_2 = 94°C + 273 = 367 K
   - V_2 = 2000 mL ~ 2 L

$$\frac{P1V1}{T1} = \frac{P2V2}{T2} \qquad \frac{89\ x\ 17}{340} = \frac{P1\ x\ 2}{367}$$

$$\frac{1513}{340} = \frac{P1\ x\ 2}{367}$$

*cross multiply 1513 x 367 = 340 x 2 x P_2

$$\frac{555271}{680} = \frac{680\ x\ P_2}{680}$$

P_2 = 817 atm

4. 160 K or -113 °C
   - V_1 = 2.9 L
   - P_1 = 5.0 atm
   - T_1 = 50.0°C + 273 = 323 K
   - T_2 = ?
   - V_2 = 2.4 L
   - P_2 = 3.0 atm

$$\frac{P1V1}{T1} = \frac{P2V2}{T2} \qquad \frac{5\ x\ 2.9}{323} = \frac{3\ x\ 2.4}{T2}$$

$$\frac{14.5}{323} = \frac{7.2}{T2}$$

*cross multiply 14.5 x T_2 = 323 x 7.2

$$\frac{14.5\ x\ T_2}{14.5} = \frac{2325.6}{14.5}$$

T_2 = 160 K – 273 = -113 °C

5. Given:
   - P_1 = 1 atm
   - P_2 = 3 atm
   - V_2 = 2 mL
   - V_1 = ?

P_1 x V_1 = P_2 x V_2

1 x V_1 = 3 x 2

V_1 = 6 mL

Ideal Gas Law Practice

1. Given: PV = nRT ~ T = PV / nR
   - n = 4.0 mol
   - P = 5.6 atm
   - V = 12 L
   - R= 0.0821 $\frac{L\ atm}{mol\ K}$

   T = (5.6 x 12) / (4.0 x 0.0821)

   T = 204 K – 273 = -68°C

2. Given: PV = nRT ~ n = PV / RT
   - P = 121.56 kPa
   - V = 31 L
   - T = 87°C + 273 = 360 K
   - R = 8.31 $\frac{L\ kPa}{mol\ K}$

   n = (121.56 x 31) / (8.31 x 360)

   n = 1.26 mol

3. Given: PV = nRT ~ P = nRT / V
   - n = 0.153 mol
   - V = 926 mL ~ 0.926 L
   - T = 32°C + 273 = 305 K
   - R = 8.31 $\frac{L\ kPa}{mol\ K}$

   P = (0.153 x 8.31 x 305) / (0.926)

   P = 418 kPa

4. Given: PV = nRT ~ n = PV / RT
   - P = 0.50 atm
   - V = 25 L
   - T = 300 K
   - R = 0.0821 $\frac{L\ atm}{mol\ K}$

   n = (0.5 x 25) / (0.0821 x 300)

   n = 0.507 mol ($\frac{40\ g}{1\ mol}$) = 20 g Argon

5. Given: PV = nRT ~ T = PV/nR
   - n = 17 g Cl_2 x ($\frac{1\ mol}{71\ g}$) = 0.239 mol
   - 743 mmHg x ($\frac{1\ atm}{760\ mmHg}$) = 0.978 atm
   - V = 12.1 L

   T = (0.978 x 12.1) / (0.239 x 0.0821)

   T = 373 K – 273 = 100°C