Answer Key

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IA																	VIIIA
1 H 1.008	IIA											IIIA	IVA	VA	VIA	VIIA	2 He 4.002
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	IIIB	IVB	VB	VIB	VIB	VIIIB	VIIIB	VIIIB	IB	IIB	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.70	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.30
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (97.9)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr 223.0	88 Ra 226.0	89 Ac 227.0															

57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
89 Ac 227.0	90 Th 232.0	91 Pa 238.0	92 U 238.0	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

Exam Rules & Guidelines

- For any problem that requires a calculation, you must show how you got your answer, using a clear, step-by-step solution. In most cases, this means that you need to show conversion factors with units cancelling. For molar mass calculations (only), you may omit the units, although it's a good idea to write "g/mol" after each molar mass that you calculate.
- You may not use any calculator or device that can accommodate text entry and/or that has the letters A through Z on the front.
- No books, notes, or scratch paper.
- Please do not wear hats, hoods, headphones/earphones or sunglasses.
- Please put a box or (circle) around each calculated answer.
- Good luck!

1 decagram (dag) = 10 gram (g)
1 hectogram (hg) = 10^2 g
1 kilogram (kg) = 10^3 g
1 megagram(Mg) = 10^6 g
1 gigagram (Gg) = 10^9 g
1 teragram (Tg) = 10^{12} g
1 petagram (Pg) = 10^{15} g
1 exagram (Eg) = 10^{18} g
1 zettagram (Zg) = 10^{21} g
1 yottagram (Yg) = 10^{24} g

1 gram = 10 decigrams (dg)
1 gram = 10^2 centigrams (cg)
1 gram = 10^3 milligrams (mg)
1 gram = 10^6 micrograms (μg)
1 gram = 10^9 nanograms (ng)
1 gram = 10^{12} picograms (pg)
1 gram = 10^{15} femtograms (fg)
1 gram = 10^{18} attograms (ag)
1 gram = 10^{21} zeptograms (zg)
1 gram = 10^{24} yoctograms (yg)

1 pound (lb) = 453.6 grams
1 ton = 2000 lb
1 gallon (gal) = 3.785 liters (L)
1 inch (in) = 2.54 centimeters (cm)
1 milliliter (mL) = 1 cubic centimeter (cm^3)
1 gallon = 4 quarts (qt)
1 quart = 2 pints (pt)
1 pint = 2 cups
1 cup = 8 fluid ounces (fl.oz.)
1 fl.oz. = 2 tablespoonsful (tbsp.)
1 tbsp. = 3 teaspoonsful (tsp.)

1 mile (mi) = 5280 feet (ft)
1 foot = 12 in
1 year = 365.25 days
1 hour (hr) = 60 minutes (min)
1 min = 60 seconds (s)

1 atmosphere (atm) = 760 torr
1 torr = 1 millimeter of mercury (mm Hg)

$K = °C + 273$

Speed of light = $c = \lambda f = 3.00 \times 10^8$ m/s
Planck's constant = $h = 6.626 \times 10^{-34}$ J·s
Energy: $E = hf = hc/\lambda$
f = frequency
λ = wavelength
1 Hertz (Hz) = 1 s^{-1} = 1/s
1 eV = 1.602×10^{-19} J
1 J = 1 kg·m^2/s^2
The Coulomb (C) is a unit of charge.
Proton charge-to-mass ratio = 9.58×10^7 C/kg
Proton charge = 1.60×10^{-19} C.
Mass of electron = 9.1×10^{-31} kg

1 mole = 6.022×10^{23} things
Molar mass is grams per mole
Density is mass divided by volume
PV = nRT
R = 0.0821 (L·atm)/(K·mol)
$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$

Acres, mi^2, and ft^2 are all units of area:
1 acre = 43,560 square feet (ft^2)
1 square mile (mi^2) = 640 acres

Molarity is moles of solute per liter of solution.

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

Percent = (part/whole) × 100

$[H^+] = 10^{-pH}$

Mass percent, % (m/m) is mass units per 100 mass units, for any mass unit.

Volume percent, % (v/v) is volume units per 100 volume units, for any volume unit.

Mass/Volume percent, % (m/v), is grams per 100 mL.

Answer Key

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1. [8 pts] A cylinder contains 26.5 L of oxygen gas at 1.8 atm and 298 K. How many moles of gas are in the cylinder?

$PV = nRT$ ①

$n = \frac{PV}{RT} = \frac{(1.8\text{ atm})(26.5\text{ L})}{(.0821 \frac{\text{L}\cdot\text{atm}}{\text{K}\cdot\text{mol}})(298\text{ K})} = \boxed{1.9\text{ mol}}$ O_2 ① Ans ① sf

2.0 mol okay (with .08206)

12

2. [12 pts] A bag of potato chips contains 535 mL of air at 25°C and 765 mm Hg. Assuming the bag does not break, what will be its volume at the top of a mountain where the pressure is 442 mm Hg and the temperature is 5.0°C?

$T_1 = 25 + 273 = 298\text{ K}$ ①

$T_2 = 5.0 + 273.15 = 278.2\text{ K}$ ①

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ ①

$V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{(765\text{ mm Hg})(535\text{ mL})(278.2\text{ K})}{(298\text{ K})(442\text{ mm Hg})} = \boxed{864\text{ mL}}$ ① Ans ① sf ① units

8

3. [8 pts] A scuba diver with a lung capacity of 5.5 liters inhales a lungful of air at a depth of 45 meters where the pressure is 5.8 atm. If the diver were to ascend to the surface, where the pressure is 1.0 atm, while holding his breath, to what volume would the air in his lungs expand?

$P_1V_1 = P_2V_2$ ①

$V_2 = \frac{P_1V_1}{P_2} = \frac{(5.8\text{ atm})(5.5\text{ L})}{1.0\text{ atm}} = \boxed{32\text{ L}}$ ① Ans ① sf ① units

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Answer Key

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4. [14 pts] What volume of 0.125 M H_2SO_4 solution is required to neutralize 24.95 mL of 0.295 M KOH solution? (*Start with a balanced equation.*)

14

$$H_2SO_4 + 2KOH \longrightarrow K_2SO_4 + 2H_2O$$

(2) Bal.

V ? | 24.95 mL
0.125 M | 0.295 M

$$24.95\ mL\ KOH \left(\frac{1\ L}{1000\ mL}\right)\left(\frac{.295\ mol\ KOH}{1\ L}\right)\left(\frac{1\ mol\ H_2SO_4}{2\ mol\ KOH}\right)\left(\frac{1\ L}{0.125\ mol\ H_2SO_4}\right)$$

$$= \boxed{0.0294\ L\ H_2SO_4}$$

(1) Ans (1) sf (1) units

5. [22 pts] A gaseous hydrocarbon is decomposed in the laboratory and found to contain 82.66% carbon and 17.34% hydrogen by mass. The mass of 158 mL of the gas, measured at 556 mm Hg and 25°C, is determined to be 0.275 grams. What is the molecular formula of the gas?

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Assume 100g

$$17.34\ g\ H \times \left(\frac{1\ mol\ H}{1.008\ g}\right) = 6.8826\ mol\ H \;/\; 6.8826 = 1 \times 2 = 2$$

$$82.66\ g\ C \times \left(\frac{1\ mol\ C}{12.01\ g}\right) = 17.202\ mol\ H \;/\; 6.8826 = 2.5 \times 2 = 5$$

EF=8

C_2H_5 = empirical formula (2)

Molar mass of empirical formula = $(12 \times 2) + (1 \times 5) = 29\ g/mol$

Find molar mass of compound = $\frac{.275\ g}{.004724\ moles} = 58\ g/mol$ → $\frac{58}{29} = 2$

MF=6 MM=8

$PV = nRT$

$$n = \frac{PV}{RT} = \frac{(556\ mm\ Hg)\left(\frac{1\ atm}{760\ mm\ Hg}\right)(158\ mL)\left(\frac{1\ L}{1000\ mL}\right)}{\left(.0821\ \frac{L \cdot atm}{K \cdot mol}\right)(298\ K)} = .004724$$

$T = 25 + 273 = 298\ K$

C_4H_{10}

EF = 8
mole calc = 8

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Answer Key

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6. [16 pts] A "hard water" solution contains 4.8 grams of calcium chloride. What mass of potassium phosphate should be added to the solution to completely precipitate all of the calcium? (*Start with a balanced equation.*)

$$3\,CaCl_2 + 2\,K_3PO_4 \rightarrow Ca_3(PO_4)_2 + 6\,KCl$$

4.8 g ? g (2) – Balanced

$$4.8\,g\,CaCl_2 \times \left(\frac{1\,mol\,CaCl_2}{110.98\,g\,CaCl_2}\right)\left(\frac{2\,mol\,K_3PO_4}{3\,mol\,CaCl_2}\right)\left(\frac{212.27\,g\,K_3PO_4}{1\,mol\,K_3PO_4}\right) = 6.1\,g\,K_3PO_4$$

(1) Ans, (1) sf, (1) units

molar masses

(1) $CaCl_2 = 40.08 + (35.45 \times 2) = 110.98$ g/mol

(1) $K_3PO_4 = (39.10 \times 3) + 30.97 + (16.00 \times 4) = 212.27$ g/mol

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7. [22 pts] For a solution prepared by adding 3.00 g of KOH to 100. g of water.
   3 a. What is the solvent? water
   3 b. What is the solute? KOH
   7 c. Calculate the mass percent of the solution.
   9 d. Assuming that the density of the solution is 1.08 g/mL, calculate the molarity of the solution.

(c) $\text{mass \%} = \frac{3.00\,g\,KOH}{(100. + 3.00)\,g\,\text{solution}} \times 100 = 2.91\%$ (1) Ans (1) sf

mass % = $\frac{\text{solute}}{\text{solution}} \times 100$

(d) $\text{Molarity} = \frac{mol}{L} = \frac{(3.00\,g\,KOH)\left(\frac{1\,mol}{56.108\,g\,KOH}\right)}{(103\,g\,\text{solution})\left(\frac{1\,mL}{1.08\,g}\right)\left(\frac{1\,L}{1000\,mL}\right)} = 0.561\,M$

.05347

(1) ans (1) sf

molar mass KOH

39.10
16.00
1.008
56.108 g/mol

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Answer Key

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④ each

20

8. [20 pts] Balance these chemical equations:

$2\ C_2H_2 + 5\ O_2 \rightarrow 4\ CO_2 + 2\ H_2O$ A

$(NH_4)_3PO_3 + Al(HSO_3)_3 \rightarrow AlPO_3 + 3\ NH_4HSO_3$ C

$2\ Pb(NO_3)_2 \rightarrow 2\ PbO + 4\ NO + 3\ O_2$ E

$4\ HCl + O_2 \rightarrow 2\ H_2O + 2\ Cl_2$ D or A

$4\ K + O_2 \rightarrow 2\ K_2O$ B or A

20

9. [20 pts] Classify each of the above reactions by placing the appropriate letter on the right side of the page next to each equation. Use each letter only once.

④ each

a. Combustion
b. Combination
c. Double displacement
d. Single displacement
e. Decomposition

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10. [6 pts] What volume of a 2.25 % v/v solution could you prepare using 42.0 gallons of ethanol and an unlimited amount of water?

$$42.0 \text{ gal ethanol} \left(\frac{100 \text{ gal solution}}{2.25 \text{ gal ethanol}}\right) = 1870 \text{ gal solution}$$

(1) Ans, (1) sf, (1) units

22

11. ~~[24~~ 22 pts] Please use the box to the right of each statement to answer T (if the statement is true) or F (if the statement is false) for each of the following statements. Ambiguous answers will be assumed to be incorrect.

(2) each ×11

T	The solubility of sugar in water decreases as the temperature of the solution decreases.
F	In a solution of sodium bromide in water, the oxygen atom in the water molecule is attracted to the bromide ion.
F	The relationship between the pressure and temperature of a gas at constant volume is: $P_1T_1 = P_2T_2$.
T	Aqueous sodium chloride is a mixture.
X	~~Polar compounds are more soluble in polar solvents than in polar solvents.~~
F	Water is a linear molecule. $2H_2 + O_2 \rightarrow 2H_2O$
T	When 10 moles of oxygen react completely with 10 moles of hydrogen to form water, hydrogen is the limiting reactant.
F	When 10 moles of oxygen react completely with 10 moles of hydrogen to form water, 20 moles of water are formed.
T	A strong electrolyte will conduct electricity better than a weak electrolyte.
T	At constant pressure, the volume of a sample of gas will decrease with decreasing temperature.
T	At constant volume, the pressure of a sample of gas will decrease when some of the sample is removed.
F	The boiling point of an aqueous sodium chloride solution is lower than the boiling point of pure water.

$10\ H_2 \times \frac{2}{2} = 10\ H_2O$
$10\ O_2 \times \frac{2}{1} = 20\ H_2O$

10

12. [10 pts] Which of the following are solutions? (*Choose one or more.*)

(a) Salt and water mixture
b. Oil and water mixture
c. Sand and water mixture
d. Blueberry muffin
(e) Sterling silver cup

(2) each ×5

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Answer Key

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13. [32 pts] You've learned that an aqueous solution contains some gold(III) nitrate, and that you can collect gold metal by reacting it with elemental tin according to the following reaction: Bal = 2

2

3 $Sn_{(s)}$ + 2 $Au(NO_3)_3\,(aq)$ → 3 $Sn(NO_3)_2\,(aq)$ + 2 $Au\,(s)$

14 a. What mass of gold could you obtain from 150.0 Liters of a 4.75×10^{-3} M gold(III) nitrate solution if you had 150.0 grams of tin metal?

$$150.0\,L\ Au(NO_3)_3 \left(\frac{4.75\times10^{-3}\,mol\ Au(NO_3)_3}{1\,L}\right)\left(\frac{2\,mol\ Au}{2\,mol\ Au(NO_3)_3}\right)\left(\frac{197.0\,g\ Au}{1\,mol\ Au}\right) = \boxed{140.4\,g\ Au}$$

(2) choice

$$150.0\,g\ Sn\left(\frac{1\,mol\ Sn}{118.7\,g\ Sn}\right)\left(\frac{2\,mol\ Au}{3\,mol\ Sn}\right)\left(\frac{197.0\,g\ Au}{1\,mol\ Au}\right) = 166.0\,g\ Au$$

(1) ans (1) SF (1) units

2 b. What is the limiting reactant in the above experiment? $\boxed{Au(NO_3)_3}$ (2)

6 c. If you actually ended up with 45.0 grams of gold, what is the percent yield of your reaction?

$$\%\ Yield = \frac{Actual}{Theoretical}\times100 = \frac{45.0\,g}{140.4\,g}\times100 = \boxed{32.1\,\%}$$

(1) ans (1) SF

8 d. How many grams of the excess reactant are left unreacted?

166.0
− 140.4
25.6 g Au could have been formed.

$$25.6\,g\ Au\left(\frac{1\,mol\ Au}{197.0\,g}\right)\left(\frac{3\,mol\ Sn}{2\,mol\ Au}\right)\left(\frac{118.7\,g}{1\,mol\ Sn}\right) = \boxed{23.1\,g\ Sn}$$

(1) ans leftover (1) SF

OR

$$140.4\,g\ Au\left(\frac{1\,mol\ Au}{197.0\,g}\right)\left(\frac{3\,mol\ Sn}{2\,mol\ Au}\right)\left(\frac{118.7\,g}{1\,mol\ Sn}\right) = 126.9\,g\ Sn$$ used up

150.0
−126.9
$\boxed{23.1\,g\ Sn}$ leftover

32