1																	18
1 H 1.008	2											13	14	15	16	17	2 He 4.003
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	3	4	5	6	7	8	9	10	11	12	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 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.64	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
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 (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.20	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (267)	105 Db (268)	106 Sg (269)	107 Bh (270)	108 Hs (270)	109 Mt (278)	110 Ds (281)	111 Rg (282)	112 Cn (285)	113 Nh (286)	114 Fl (289)	115 Mc (290)	116 Lv (293)	117 Ts (294)	118 Og (294)

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
90 Th 232.04	91 Pa 231.04	92 U 238.03	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 (266)

constants

$R = 0.08206$ L atm/mol K

$R = 8.314$ J/mol K

$N_A = 6.022 \times 10^{23}$ /mol

$h = 6.626 \times 10^{-34}$ J·s

$c = 3.00 \times 10^{8}$ m/s

$g = 9.81$ m/s^2

conversions

1 atm = 760 torr

1 atm = 101325 Pa

1 atm = 1.01325 bar

1 bar = 10^5 Pa

°F = °C(1.8) + 32

K = °C + 273.15

conversions

1 in = 2.54 cm

1 ft = 12 in

1 yd = 3 ft

1 mi = 5280 ft

1 lb = 453.6 g

1 ton = 2000 lbs

1 tonne = 1000 kg

1 gal = 3.785 L

1 gal = 231 in^3

1 gal = 128 fl oz

1 fl oz = 29.57 mL

water data

$C_{s,ice} = 2.09$ J/g °C

$C_{s,water} = 4.184$ J/g °C

$C_{s,steam} = 2.03$ J/g °C

$\rho_{water} = 1.00$ g/mL

$\rho_{ice} = 0.9167$ g/mL

$\rho_{seawater} = 1.024$ g/mL

$\Delta H_{fus} = 334$ J/g

$\Delta H_{vap} = 2260$ J/g

$K_w = 1.0 \times 10^{-14}$

This extra practice set can be used to test your knowledge for the upcoming exam.

1. Which of the following is the main pollutant produced when butane is combusted under oxygen-starved conditions (oxygen is in limited supply)?

● a. CO

b. O_3

c. NO_x

d. H_2O

e. CO_2

Explanation: Carbon monoxide is produced under these conditions. Water is produced, too, but it is not a pollutant. Carbon dioxide is going to be produced, but it is more likely to be the product under oxygen-rich conditions.

---

2. When 6 moles of iron are added to 6 moles of oxygen in the following reaction to 100% completion, which species will be present in the final reaction mixture?

$$4Fe(s) + 3O_2(g) \longrightarrow 2Fe_2O_3(s)$$

a. Fe_2O_3 only

b. Fe and Fe_2O_3

● c. O_2 and Fe_2O_3

d. Fe, O_2, and Fe_2O_3

e. Fe and O_2

Explanation: This is a conceptual question dealing with determining the product and excess reagent of a stoichiometry problem. 6 moles of Fe will require 3/4 of that or 4.5 moles of oxygen gas. The 6 moles of oxygen gas is 1.5 moles "in excess". So all the iron reacts and makes the product Fe_2O_3 and there is still 1.5 moles of O_2 left as well.

---

3. Calculate the number of moles of carbon dioxide that are produced when 6.4 moles of methanol (CH_3OH) are burned with 7.8 moles of oxygen gas. You will need to write out the chemical equation and balance it on your own.

● a. 5.2 mol

b. 6.4 mol

c. 7.2 mol

d. 7.8 mol

e. 11.7 mol

Explanation: First, write out the equation for the combustion of methanol:

$$2CH_3OH(\ell) + 3O_2(g) \longrightarrow 2CO_2(g) + 4H_2O(\ell)$$

The oxygen to methanol ratio is 3:2 which means you need at least 9.6 moles of oxygen (1.5× more)to match up stoichiometrically with 6 moles of methanol. 7.8 moles is too few which means that oxygen will be the limiting reagent. Now calculate carbon dioxide from the oxygen:

$$7.8\,\text{mol}\,O_2 \times \frac{2\,\text{mol}\,CO_2}{3\,\text{mol}\,O_2} = 5.2\,\text{mol}\,CO_2$$

---

4. A sampling of air is taken in Houston on a typical warm humid day. Although there are many different gases in the sample, which of the following four gases are the top four in terms of percentage in the sample?

a. H_2O, NO_2, N_2, and O_2

b. H_2O, Ar, N_2, and O_3

c. H_2O, Ar, N_2, and CO_2

● d. H_2O, Ar, N_2, and O_2

e. H_2O, CO_2, N_2, and O_2

Explanation: Typical air consists of Ar, N_2, and O_2. On a particularly humid day, H_2O can be added to the mix as the fourth major gas. CO_2 is around 0.04

---

5. Which of the following alkanes do you expect to have the largest molecular weight?

a. pentane

b. butane

● c. heptane

d. hexane

e. ethane

Explanation: All of these alkanes will have the formula: C_nH_{2n+2}. Therefore, you are looking for the highest n-value, which is the most carbons. This corresponds to heptane in this case: 7 carbons. All the others are less than 7.

---

6. Refer to the following balanced chemical reaction for the aqueous extraction of benzocaine, the active ingredient in cough drops and other mild topical anesthetics:

$$C_9H_{11}NO_2(aq) + HNO_3(aq) \rightarrow C_9H_{11}NO_2(aq)$$

A pharmaceutical company attempts to mass produce cough drops by reacting 5.7 kg benzoate ($C_9H_{11}NO_2$, molar mass = 144 g/mol) with 5.7 kg nitric acid (HNO_3, molar mass = 63 g/mol). Nitric acid is a very dangerous chemical that should be used with extreme caution. Is this recipe a good idea for mass producing cough drops? Why or why not?

● a. No, there is a dangerous chemical left in the cough drops.

b. No, there is excess benzoate left over.

c. Yes, there is excess nitric acid but that does not matter.

d. Yes, the reactants were added in equal mole amounts so there is no excess reagent.

Explanation: The limiting reagent is what the question calls "benzoate" (it's not really benzoate), meaning there is nitric acid left over. This should be a serious concern if you are hoping to manufacture consumable products. Although the answer is correct based on the information given, the reaction and the synthesis of benzocaine is totally bogus. We will do better next time.

---

7. What is the percent composition of sodium in sodium dichromate ($Na_2Cr_2O_7$)?

a. 8.77%

b. 23.9%

c. 83.3%

d. 25.2%

● e. 17.6%

Explanation: Use the mass of sodium divided by the total molar mass.

$$\frac{2 \times 23}{(2 \times 23 + 2 \times 52.00 + 7 \times 16)} \times 100\%$$

$$= 17.6\%$$

---

8. There is a formula to figure out the number of carbons and hydrogen for any saturated hydrocarbon. Using this formula, determine the molecular formula of an alkane with 18 carbon atoms.

a. $C_{18}H_{18}$

b. $C_{18}H_{36}$

c. $C_{18}H_{20}$

● d. $C_{18}H_{38}$

e. $C_{18}H_{26}$

Explanation: The formula is C_nH_{2n+2}. This gives $C_{18}H_{36+2}$

---

9. A 40 L flexible container has a pressure of 32 psi. What is the pressure when the container is compressed to 23 L?

a. 18 psi

b. 68 psi

c. 63 psi

● d. 56 psi

e. 29 psi

Explanation: This is a Boyle's Law problem:

$$P_1V_1 = P_2V_2$$

$$56 = \frac{(40)(32)}{(23)}$$

---

10. Nitrogen gas reacts with hydrogen gas to produce ammonia (NH_3). Write the balanced reaction for this process.

●a. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

b. $2N(g) + 3H_2(g) \rightarrow 2NH_3(g)$

c. $3N_2(g) + 6H_2(g) \rightarrow 4NH_3(g)$

d. $N(g) + 3H(g) \rightarrow NH_3(g)$

e. $N_2(g) + H_2(g) \rightarrow NH_3(g)$

Explanation: First you must remember that both nitrogen gas and hydrogen gas are diatomic molecules. Therefore, you are reacting N_2 and H_2 to form ammonia. The unbalanced reaction is:

$$N_2(g) + H_2(g) \rightarrow NH_3(g)$$

Then balance:

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

---

11. How many nitrogen atoms are present in a sample of 1.87 moles of nitrogen gas?

a. 1.13×10^{24}

b. 5.63×10^{23}

c. 6.21×10^{-24}

●d. 2.25×10^{24}

Explanation: Convert from the number of moles to number of molecules and then multiply by 2 to account for the 2 nitrogen atoms in each diatomic N_2:
$(1.87\,\text{mol}\,N_2)\left(\frac{6.022\times10^{23}\,N_2\,\text{molecules}}{\text{mol}\,N_2}\right)\left(\frac{2\,\text{N atoms}}{N_2\,\text{molecule}}\right)$
$= 2.25 \times 10^{24}$ atoms

---

12. Consider the balanced chemical reaction shown below:

$$2Al_2O_3(s) \longrightarrow 4Al(s) + 3O_2(g)$$

What is the mass of Al_2O_3 necessary to form 6.00 moles of aluminum solid? The molar mass of Al_2O_3 is 101.96 g/mol.

a. 556 g

b. 459 g

c. 204 g

●d. 306 g

e. 408 g

Explanation: First solve for the number of moles of Al_2O_3 using the mole ratio:

$$6\,\text{mol Al} \times \frac{2\,\text{mol}\,Al_2O_3}{4\,\text{mol Al}} = 3\,\text{mol}\,Al_2O_3$$

Then multiply by the molar mass:

$$3\,\text{mol}\,Al_2O_3 \times 101.96\,\text{g/mol} = 305.88\,\text{g}$$

---

13. Which of the following matches the gas in its standard state to its molar mass?

a. Oxygen, 16.00 g/mol

b. Oxygen, 48.00 g/mol

c. Helium, 8.00 g/mol

●d. Nitrogen, 28.02 g/mol

Explanation: To determine the molar mass of a gas in its standard state, you should consider two things: the mass listed on the periodic table and if it is a monatomic or diatomic gas. The only correct match here is nitrogen (N_2) and its molar mass is 14.01×2

---

14. Approximately 14.78 moles of an unknown metal weighs 398.76 g. What is the identity of this metal?

a. Fe

b. Zn

c. Mg

d. Cu

● e. Al

Explanation: This is a composition stoichiometry problem. Solve directly for the molar mass and use the periodic table to identify the metal.

$$\frac{398.76\,\text{g}}{14.78\,\text{mol}} = 26.98\,\text{g/mol}$$

Refer to the periodic table to see that this best matches Al.

---

15. The gas known as the silent killer is the primary culprit in fatalities caused by the unsafe use of personal generators. This gas is produced by the incomplete combustion of a fuel. What gas is this?

a. NO_x

● b. CO

c. H_2O_2

d. O_3

e. CO_2

Explanation: Carbon monoxide is a product of incomplete combustion and is known as the silent killer.

---

16. Consider the following data for the elevations of four different cities:

Moab, UT: 4,026 ft

Flagstaff, AZ: 6,909 ft

New Orleans, LA: -1.500 ft

Estes Park, CO: 7,522 ft

Which city will have the lowest predicted atmospheric pressure?

● a. Estes Park

b. Moab

c. Flagstaff

d. New Orleans(ℓ)

Explanation: You can predict that the lowest atmospheric pressure will be the highest elevation. This corresponds to Estes Park.

---

17. In an experimental set up, a scientist places two equal masses of gold and silver into separate beakers with identical starting volumes of water. The density of gold is 19.3 g/cm^3 and the density of silver is 10.5 g/cm^3. Which beaker will have the greater final volume?

a. Both beakers will have equal final volumes

● b. Silver

c. Gold

Explanation: The less dense metal (silver) will require more volume to have a mass equal to the more dense metal (gold). Therefore, the beaker with water and silver will have the greatest final volume.

---

18. What is a reasonable estimation for the percent of carbon dioxide in the troposphere?

a. 66%

b. 3%

c. 12%

d. 40%

● e. 0.04%

Explanation: Carbon dioxide makes up 0.04% of the atmosphere. This can be reasonably estimated because it is a trace gas and none of the other choices would reasonably represent a trace gas.

---

19. Which of the following substances do you expect to have the lowest density at room temperature?

● a. $CH_4(g)$

b. $H_2O(\ell)$

c. Fe(s)

d. $CH_3OH(\ell)$

e. $CH_3CH_2OH(\ell)$

Explanation: A gas will have the lowest density out of solids, liquids, and gases. Methane, $CH_4(g)$, will have the lowest density of the answer choices provided.

---

20. Which layer of the atmosphere includes the air we actively breathe?

● a. troposphere

b. stratopause

c. mesosphere

d. exosphere

e. thermosphere

Explanation: The start of the troposphere is the earth's surface, so this is the layer that includes the air we actively breathe.

---

21. Which of the following is a pollutant that is not directly produced by combustion?

● a. O_3

b. CO

c. NO_x

d. CO_2

e. H_2O

Explanation: CO_2, CO, and NO_x are all produced by combustion. CO_2 is not really a pollutant and H_2O definitely is not. O_3 is a pollutant that is not formed by combustion.

---

22. Approximately how many oxygen atoms are in 1.11 moles carbon dioxide (CO_2)?

a. 6.68×10^{23}

b. 2.34×10^{24}

c. 1.84×10^{-24}

● d. 1.34×10^{24}

Explanation: Use Avogadro's number to convert from moles to molecule, and then multiply by two to account for the two oxygen atoms:

$1.34 \times 10^{24} = 1.11\,\text{mol} \times 6.022 \times 10^{23} \times 2$

---

23. Which of the following puts into words a true relationship that can be made from the ideal gas law?

a. pressure and temperature are inversely proportional

● b. number of moles and volume are directly proportional

c. temperature and the ideal gas constant are inversely proportional

d. pressure and volume are directly proportional

e. temperature and pressure are inversely proportional

Explanation: The only true relationship here is the the number of moles and volume are directly proportional. Anything on the same side of $PV = nRT$ is inversely proportional and anything on the opposite side is directly proportional. It is important to realize that R, the ideal gas constant is...constant.

---

24. Which of the following best describes the purpose of the mole in chemistry?

● a. The mole is an Avogadro's number worth of elementary entities, which allows scientists to use macroscopic units (g/mol) with the atomic mass values on the periodic table.

b. A mole is an arbitrary quantity, but it is easy to use for calculations.

c. A molecule is an Avogadro's number worth of moles, which allows scientists to conveniently use amu to measure mass in the lab.

d. A molecule is a packet of 6.022×10^{23} moles.

Explanation: A mole is a packet of 6.022×10^{23} elementary entities. This is the conversion factor between amu and g/mol, allowing us to use macroscopic units with the periodic table values.

---

25. Which of the following statements is true?

a. there is a significantly higher percentage of carbon dioxide in an inhale than in an exhale

● b. there is a significantly higher percentage of carbon dioxide in an exhale than in the atmosphere

c. there is a significantly higher percentage oxygen in an exhale than in the atmosphere

Explanation: Humans utilize oxygen and produce carbon dioxide when running metabolic processes in the body. An exhale contains 100x more carbon dioxide than an inhale (from the atmosphere).

---

26. A hot air balloon must be expanded to a volume of 2800 m^3 in order to sustain flight. If a deflated hot air balloon at 298 K occupies 2118 m^3, what temperature is necessary to inflate the balloon enough to fly?

a. 225 K

b. 309 K

c. 273 K

d. 591 K

● e. 394 K

Explanation: Use Charles' Law:

$$V_1/T_1 = V_2/T_2$$

$$2118\,m^3/298\,K = 2800\,m^3/T_2$$

$$T_2 = 394\,K$$

---

27. Which of the following is NOT a task performed by the catalytic converter in your car?

a. complete the oxidation of CO to CO_2

b. help to oxidize remaining volatile organic compounds to CO_2 and H_2O

c. convert NO_x to N_2

● d. convert CO_2 back into gasoline fuel

Explanation: Unfortunately, catalytic converters cannot give you infinite gasoline, which is implied by the answer choice: convert CO_2 back into gasoline fuel. The other answer choices highlight the three main purposes of the catalytic converter.

---

28. Carl was hot and decided to whip up a batch of Kool-Aid. He followed the instructions pouring the packet of Cherry Kool-Aid and a cup of sugar into two quarts of water. A perfect batch - nice and cherry red, everything dissolved nicely. Which of the following is the best description of Carl's cherry Kool-Aid?

a. It's a heterogeneous mixture.

b. It's a compound.

c. It's an element.

● d. It's a homogeneous mixture

e. It's a pure substance.

Explanation: Once "everything dissolved", Carl's Kool-Aid was definitely a homogeneous mixture. A tasty one at that.

---

29. What best describes the temperature of our atmosphere as altitude increases from sea level to the thermosphere?

a. The atmospheric temperature steadily decreases.

b. The atmospheric temperature steadily increases.

● c. The atmospheric temperature initially decreases, but reverses trend several times in the pauses between atmospheric layers.

d. The atmospheric temperature initially increases, then reverses in the middle of each atmospheric layer.

Explanation: Temperature initially decreases, but reverses trend several times in the pauses between atmospheric layers

---

30. Calculate the volume that 3.96 moles of an ideal gas occupies at 2.94 atm and 37 °C.

a. 4.09 L

● b. 34.3 L

c. 35.6 L

d. 3110 L

e. 311 L

f. 45.9 L

Explanation: Use $PV = nRT$, solve for V... $V = \frac{(3.96\,\text{mol})(0.08206\,\text{L atm/mol K})(310.15\,\text{K})}{2.94\,\text{atm}} = 34.3\,\text{L}$

Remember to bubble in ALL your answers BEFORE time is called. Double check your name, uteid, and version number before you turn in your bubblesheet. You must keep your exam for future reference. Please do not lose it. We will not replace it.