| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 H 1.008 | | | | | | | | | | | | | | | | | 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 | | | | | | | | | | | 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 exam should have exactly 25 questions. Each question is equally weighted at 4 points each. Bubble in your answer choices on the bubblehseet provided. Your score is based on what you bubble on the bubblesheet and not what is circled on the exam.

1. Use the data below for three substances at room temperature:

Fe(s), 7874 $kg/m^3$

$NH_3$(g), 0.730 $kg/m^3$

$CH_3CH_2OH$(ℓ), 789 $kg/m^3$

$C_2H_6$(g), 0.784 $kg/m^3$

If equal masses of each substance is collected at room temperature, which one will have the greatest volume?

a. Fe(s)

●b. $NH_3$(g)

c. $CH_3CH_2OH$(ℓ)

d. $C_2H_6$(g)

e. All of these will have identical volumes.

**Explanation:** The greatest volume will have the lowest density. This corresponds to the data provided for $NH_3$.

---

2. What is the percent composition by mass of sulfur in potassium thiosulfate ($K_2S_2O_3$)?

●a. 33.70%

b. 16.85%

c. 41.08%

d. 25.22%

e. 50.55%

**Explanation:** Calculate the total mass and calculate the mass percent by taking the ratio of sulfur mass to the total mass:

$$\frac{2 \times 32.07}{2 \times 39.10 + 2 \times 32.07 + 3 \times 16.00}$$

$$\times 100\% = 33.70\%$$

---

3. In contrast to what you should be consuming as dietary salt (a combination of NaCl, iodide, and trace minerals), some salt products in the grocery are 100% NaCl. A 100% NaCl product can be described as...

●a. a solid, a compound, and a pure substance

b. a solid, a compound, and a homogenous mixture

c. a solid, an element, and a pure substance

d. a solid, an element, and a homogenous mixture

e. a solid, a compound, and a heterogenous mixture

**Explanation:** NaCl is a compound in the solid phase. Because it is 100%, it is a pure substance, as opposed to the other NaCl products, which are mixtures.

---

4. What is the mass of 3.12 moles of oxygen gas?

●a. 99.8 g

b. 49.9 g

c. 32.0 g

d. 98.7 g

e. 10.3 g

**Explanation:** moles × molar mass = mass

$$99.8\,\text{g} = 3.12\,\text{mol} \times 32.00\,\text{g/mol}$$

---

5. A 1.2 L sample of ozone ($O_3$) is collected at 1 atm pressure and 299 K. How many oxygen atoms are in this sample?

a. $9.83 \times 10^{21}$

b. $2.44 \times 10^{-24}$

c. $2.95 \times 10^{22}$

●d. $8.84 \times 10^{22}$

e. $1.81 \times 10^{24}$

**Explanation:** Solve for $n$ using the ideal gas law and then convert this to number of oxygen atoms.

$$n = PV/RT = \frac{(1)(1.2)}{(0.08206)(299)}$$

$$n = 0.04890785$$

This number represents the number of ozone moles. To now go to oxygen atoms, we need to convert to oxygen moles (x3) and then oxygen atoms (x$N_a$).

$$0.04890785 \times 3 \times (6.022 \times 10^{23})$$

$$= 8.84 \times 10^{22}$$

---

6. What is the sum of coefficients when you balance the chemical equation below to the smallest whole number coefficients?

$$\mathrm{FeS(s) + O_2(g) \longrightarrow Fe_2O_3(s) + SO_2(g)}$$

a. 11

b. 15

●c. 17

d. 13

e. 28

f. 4

**Explanation:**

$$\mathrm{4FeS + 7O_2 \longrightarrow 2Fe_2O_3 + 4SO_2}$$

$$4 + 7 + 2 + 4 = 17$$

---

7. Consider the unbalanced chemical equation below:

$$\mathrm{Mg + HNO_3 \longrightarrow Mg(NO_3)_2 + H_2}$$

First balance this reaction. Which species are in your final reaction mixture after 1.5 moles of Mg and 6 moles of $HNO_3$ react to completion?

a. $Mg(NO_3)_2$, $H_2$, and excess Mg

b. only $Mg(NO_3)_2$ and $H_2$

●c. $Mg(NO_3)_2$, $H_2$, and excess $HNO_3$

d. only $Mg(NO_3)_2$

e. only $H_2$

**Explanation:** First balance the equation:

$$\mathrm{Mg + 2HNO_3 \longrightarrow Mg(NO_3)_2 + H_2}$$

Now you can use the coefficients to help you find the limiting reagent:

$$1.5\,\mathrm{mol\,Mg} \times \frac{1\,\mathrm{rxn}}{1\,\mathrm{mol\,Mg}} = 1.5\,\mathrm{rxn}$$

$$6\,\mathrm{mol\,HNO_3} \times \frac{1\,\mathrm{rxn}}{2\,\mathrm{mol\,HNO_3}} = 3\,\mathrm{rxn}$$

These calculations help illustrate that Mg is the limiting reagent and $HNO_3$ is in excess. This means the final reaction mixture will not only have the products, but also excess $HNO_3$.

---

8. Consider the balanced chemical reaction shown below for the decomposition of mercury(II) oxide:

$$\mathrm{2HgO(s) \longrightarrow 2Hg(\ell) + O_2(g)}$$

How many total moles of products are formed when 8 moles HgO decomposes into Hg and $O_2$?

●a. 12 moles

b. 8 moles

c. 6 moles

d. 16 moles

e. 20 moles

**Explanation:** For every mole of HgO that decomposes, you form one mole of Hg and half a mole of $O_2$. Given 8 moles of HgO to start, the final number of moles is 12 = 8 + 4.

---

9. Consider the following balanced chemical equation:

$$2C_2H_6(g) + 7O_2(g) \longrightarrow 4CO_2(g) + 6H_2O(g)$$

The ethane fuel is burned in a hot engine and the products are isolated at 517 K and 1.04 atm pressure. What is the total volume of these isolated products when 1.74 moles of ethane are burned with excess oxygen?

●a. 355 L

b. 71.0 L

c. 710 L

d. 284 L

e. 426 L

**Explanation:** First solve for the total number of moles and then use $PV = nRT$.

$$1.74\,\text{mol}\,C_2H_6 \times \frac{4\,\text{mol}\,CO_2}{2\,\text{mol}\,C_2H_6} = 3.48\,\text{mol}\,CO_2$$

$$1.74\,\text{mol}\,C_2H_6 \times \frac{6\,\text{mol}\,H_2O}{2\,\text{mol}\,C_2H_6} = 5.22\,\text{mol}\,H_2O$$

$$n = 8.70$$

Now plug this value into $PV = nRT$ to solve for volume:

$$V = nRT/V = (8.70)(0.08206)(517)/1.04 = 355\,\text{L}$$

---

10. Consider the following balanced chemical equation:

$$2Co_3O_4(s) \longrightarrow 6CoO(s) + O_2(g)$$

What is the mass of cobalt(II) oxide, CoO, that can be produced from 2.74 moles $Co_3O_4$?

a. 205 g

b. 1230 g

●c. 616 g

d. 362 g

e. 74.9 g

**Explanation:** Solve for the number of moles CoO that can be formed and then convert from moles to mass:

$$2.74\,\text{mol}\,Co_3O_4 \times \frac{6\,\text{mol}\,CoO}{2\,\text{mol}\,Co_3O_4} \times 74.93\,\text{g/mol}$$

$$= 616\,\text{g}$$

---

11. What is the mass density (in g/L) of $CO_2$ when 1.17 moles occupies 30.05 L at 313 K and 1 atm?

●a. 1.71 g/L

b. 0.0389 g/L

c. 000373 g/L

d. 2.57 g/L

e. 1.01 g/L

**Explanation:** You can use the number density $(n/V)$ times the molar mass. All you are doing here is converting the number of moles to mass to convert from number density to mass density. There are 51.48 g total ($1.17\,\text{mol} \times 44\,\text{g/mol}$) divided by 30.05 L, giving a mass density of 1.71 g/L.

---

12. In a severe case of "global warming" Venus has an atmospheric pressure of mostly carbon dioxide and a little bit of nitrogen. What is the total surface pressure of Venus if the pressure of $CO_2$ is 88.6 atm and the pressure of $N_2$ is 3.2?

●a. 91.8 atm

b. 85.4 atm

c. 88.6 atm

d. 3.2 atm

e. 95.0 atm

f. 45.9 atm

**Explanation:** Simply add the two pressures together to get 91.8 atm.

---

13. A gas is compressed from 12.8 L to 6.4 L. If temperature is held constant, what happens to the pressure?

●a. doubles

b. halves

c. remains constant

d. multiplies by four

e. quarters

**Explanation:** This is Boyle's Law, which describes the inverse proportionality between pressure and volume. The volume halves. Therefore, the pressure will double.

---

**14.** Which of the following is a secondary pollutant that is not directly produced by combustion? This pollutant plays a distinctively important role in our upper atmosphere, but is toxic at ground level.

a. CO

b. $CO_2$

c. $SO_x$

d. $NO_x$

●e. $O_3$

f. particulate matter

**Explanation:** Ozone is a secondary pollutant that is not directly produced by combustion

---

**15.** A container has 3 moles of helium gas, 1 mole of argon gas, and 4 moles of neon gas. The overall (total) pressure of the contain is 24 kPa. What is the partial pressure of the helium in this mixture?

●a. $P_{\text{He}} = 9$ kPa

b. $P_{\text{He}} = 6$ kPa

c. $P_{\text{He}} = 3$ kPa

d. $P_{\text{He}} = 8$ kPa

e. $P_{\text{He}} = 11$ kPa

**Explanation:** The partial pressure of helium will be the total pressure times the mole fraction of helium in the mixture.

$$P_{\text{He}} = \left(\frac{n_{\text{He}}}{n_{\text{total}}}\right) \cdot P_{\text{total}}$$

$$P_{\text{He}} = \frac{3\text{ mol He}}{8\text{ mol total}}(24\text{ kPa}) = 9\text{ kPa}$$

---

**16.** Which of the following substances (shown below in abbreviated form and/or formula) is dangerous because it is an air pollutant that can embed deep in your lungs as a solid?

●a. PM

b. $CO_2$

c. CO

d. $NO_x$

e. VOC

f. $O_3$

**Explanation:** PM (particulate matter), or soot, includes solids that can have serious impacts on the body when the particles embed deeply in your lungs.

---

**17.** A mostly deflated balloon has a volume of 0.0500 L and contains 0.00197 moles. If you exhale a breath consisting of 0.0587 moles to inflate the balloon, what is the final volume?

●a. 1.49 L

b. 0.00168 L

c. 1.68 L

d. 3.14 L

e. 0.587 L

**Explanation:** This is an Avogadro's Law problem, where volume and number of moles are directly proportional:

$$\frac{0.05\,\text{L}}{0.0197\,\text{mol}} \times .0587\,\text{mol} = 1.49\,\text{L}$$

---

**18.** Which of the following is an air pollutant that has a strong odor and is one of the key players in forming acid rain?

a. PM

b. $CO_2$

c. CO

●d. $NO_x$

e. $N_2$

f. $O_3$

**Explanation:** $NO_x$ forms acid rain. Fortunately, it also has a pungent odor so it can be easily detected by the knowledgeable chemist.

---

19. Your friend tells you that Charles' Law is the direct proportionality between volume and temperature. He then proceeds to tell you that increasing the temperature from 25 °C to 50 °C will double the volume of a sample. You, an intellectual, should say...

● a. volume and temperature are only directly proportional if you convert the temperature to Kelvin

b. actually, volume and temperature are inversely proportional, so the volume would drop to half its original volume

c. you're absolutely right, we are both so smart

**Explanation:** Charles; Law is indeed the direct proportionality between volume and temperature. However, you must be in Kelvin for this relationship to work.

---

20. What is the pressure of 0.104 moles of an ideal gas that occupies 12 L at 298 K?

a. 161 atm

● b. 0.212 atm

c. 0.411 atm

d. 0.104 atm

e. 0.0178 atm

**Explanation:** Use $PV = nRT$, solving for $P$...

$$P = \frac{nRT}{V}$$

$$P = \frac{(0.104\,\text{mol})(0.08206\,\text{L atm/mol K})(298\,\text{K})}{12\,\text{L}} = .212\,\text{atm}$$

---

21. The air we breathe on a dry day is primarily composed of which three gases...

● a. $N_2$, $O_2$, and Ar

b. O, N, and Ar

c. $O_3$, $N_2$, and Ar

d. $O_2$, $N_2$, and $H_2O$

e. $O_2$, $N_2$, and $CO_2$

f. O, N, and $CO_2$

**Explanation:** The primary components of the atmosphere are nitrogen, oxygen, and argon.

---

22. When the relative humidity is 100%, the percent of water vapor in the air is approximately...

● a. 7%

b. 100%

c. 1%

d. 20%

e. 50%

f. 78%

**Explanation:** Maximum humidity is relative to about 7%.

---

23. The partial pressure of carbon dioxide on a typical day in austin ($P_{total}$ = 750 Torr) is closest to...

● a. 0.3 Torr

b. 40 Torr

c. 112 Torr

d. 585 Torr

e. 158 Torr

**Explanation:** Carbon dioxide makes up only about 0.04% of the atmosphere. This corresponds to a partial pressure equal to about 0.3 Torr (750 Torr × 0.0004). Also, even if you didn't know or remember the 0.04% for $CO_2$, you had to know it was well below 1%. The choice of 0.3 Torr is the only answer below that threshold.

---

24. Avogadro's number ($N_A$) represents...

a. the number of moles in a measured mass of an element or compound

b. the mass of one mole of a particular element

● c. the number of any elementary entity (atoms, molecules, etc.) in a mole

d. the number of moles found in any quantity of elementary entities (atoms, molecules, etc.)

**Explanation:** Avogadro's number represents the number of atoms, molecules, or any other elementary entity in a mole.

---

25. Which of the following alkanes has the smallest molar mass?

● a. propane

b. butane

c. hexane

d. heptane

e. pentane

**Explanation:** Propane has three carbons, which is the smallest numbers out of this list. This will correlate with molar mass, meaning propane also has the smallest molar mass.

---

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.