Numerical constants may be listed below. Other needed information is given in the problem or written on the board or found in the periodic tables you will use during exam. For numerical problems, be sure to show your work, include units and circle your final answer. If several choices are given, circle the correct answer. Your written answers should be brief - just a few key words or sentences and not a long discussion. You can use your own calculator on the exam, but no notes, books, external information, or other electronic devices are to be out during exam.

\[ ^\circ C = \frac{^\circ F - 32}{1.8} \quad K = ^\circ C + 273\]

1 atm = 760 torr = 760 mm Hg = 14.7 psi = 1.01 x 10^5 N/m^2

R = 0.08206 (L atm/ mol K) \quad R = 8.31 (J/ mol K) \quad J = kg m^2 s^{-2}

1 mol = 6.02 x 10^{23} \quad h = 6.63 \times 10^{-34} \text{ Js} \quad c = 3.00 \times 10^8 \text{ m/s}

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1) One of the lowest pressures ever recorded at sea level was 0.9868 atm during Hurricane Gilbert in 1988. What is this pressure in psi (pounds per square inch).

\[ \text{psi} = 0.9868 \text{ atm} \left( \frac{14.7 \text{ psi}}{1 \text{ atm}} \right) = 14.5 \text{ psi} \]

2) Draw a plot below of Pressure (y axis) versus Temperature (x axis) for helium gas and indicate the point representing absolute zero.

\[ PV = nRT \]

3) 1.50L of an anesthetic gas at 20\(^\circ\)C would have what volume when introduced into a patient who’s body temperature is 37\(^\circ\)C?

\[ \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \]

\[ V_2 = (1.50L) \left( \frac{37 + 273}{20 + 273} \right) \]

\[ V_2 = (1.50L) \left( \frac{1.05 \text{B}}{1.05B} \right) \]

\[ V_2 = 1.59 \text{ L} \]

4) A balloon at a pressure of 1.00 atm, temperature of 300K, and volume of 2.0L is allowed to undergo a change to a new pressure of 0.333 atm and temperature of 250K as it rises to a high elevation. What will be the new volume (L) of the balloon?

\[ \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \]

\[ \frac{(1.00 \text{ atm})(2.0L)}{300K} = (0.333 \text{ atm})(V_2) \]

\[ 5.0L = V_2 \]

5) A gas was released after adding a piece of chalk to acid. The gas was trapped and occupied 2.24L at STP (T=273K) and (P=1.00 atm). How many moles of gas were released?

\[ PV = nRT \]

\[ (1.00 \text{ atm})(2.24L) = n \left( 0.08206 \frac{\text{L atm}}{\text{mol K}} \right)(273K) \]

\[ 0.10 \text{ mol} = n \]
6) What is the density (g/L) of argon if 5 moles of argon gas occupy 100L?

\[ \rho = \frac{s \text{ mol}}{100 \text{ L}} \left( \frac{40.00 \text{ g}}{\text{mol}} \right) = 2.000 \text{ g/L} \]

7) In a mixture of 0.70 mol of nitrogen, 0.20 mol of argon, and 0.50 mol of chlorine, what is the mole fraction of nitrogen \( X_{N_2} \)?

\[ X_{N_2} = \frac{0.70 \text{ mol}}{0.70 + 0.20 + 0.50 \text{ mol}} = 0.50 \]

8) 10.00 mole of He gas at a temperature of 500K and a pressure of 10.00 atm would inflate a balloon to how many liters?

\[ \frac{PV = nRT}{V} = \frac{\text{10.00 mol}}{10.00 \text{ atm}} \left( 0.08206 \frac{\text{L atm}}{\text{mol K}} \right) (500 \text{ K}) \]

\[ V = 41.0 \text{ L} \]

9) At very high pressure to do the most accurate calculation one would have to use which of the following equations of state

\[ P = nRT/V \quad P = (nRT)/(V - nb) - a \left( \frac{n^2}{V^2} \right) \quad P = nRT/V^2 \quad P = an^2/V^2 \]

10) At very low temperature the ideal gas equation is not completely accurate because the ______ of molecules becomes significant

interactions size ionization energy mass

11) In a class Demo, a chair was used to demonstrate what?

air pressure - chair was held up with two small suction cups.

12) Recall that the equation to determine average molecular speed is \( u = (3RT/M)^{1/2} \) and \( M \) is the molar mass. For Br\(_2\) at 298K what is the average speed (m s\(^{-1}\)) of the molecules?

\[ u = \left( \frac{3RT}{M} \right)^{1/2} \]

\[ u = \left( \frac{3 \times 8.31 \frac{5}{\text{mol K}} \times 298 \text{ K}}{0.1598 \text{ kg/mol}} \right)^{1/2} = \left( \frac{46490 \text{ m}^2}{\text{s}^2} \right)^{1/2} \]

13) In a mixture of gas molecules at the same temperature which of the following would have the slowest average speed: He Ne Ar Kr largest mass
14) Of the following boiling points of $184^\circ C$, $59^\circ C$, $-35^\circ C$, and $-188^\circ C$ the one that must be the boiling point of I$_2$ where the other molecules in the set are F$_2$, Br$_2$ and Cl$_2$

$$\text{I}_2 \text{ largest size so greatest VDW so highest bp}$$

15) The strongest forces holding the molecules would be present in

- solid wax
- liquid hexane
- gaseous methane

16) Recall that the rate of effusion of two gases is expressed as $\frac{\text{rate}_1}{\text{rate}_2} = \left(\frac{M_2}{M_1}\right)^{1/2}$. Therefore if the rate of effusion of He gas is 2.83 times that of an unknown gas, then the heavier unknown gas must be

$$\frac{\text{rate}_\text{He}}{\text{rate}_x} = \sqrt{\frac{M_x}{M_{\text{He}}}}$$

$$2.83 = \left(\frac{M_x}{4\text{g/mol}}\right)^{1/2}$$

$$\frac{(2.83)^2 \times 4\text{g/mol}}{\text{molar mass}} = M_x$$

$$32\text{g/mol} = M_x$$

17) Hydrogen and oxygen can be combined in the reaction below to produce electrical energy in a fuel cell. If 1.00 atm H$_2$ at a temperature of 273K fills a 24.4L container then how many grams of water could this amount of H$_2$ and an excess of oxygen produce?

$$2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{energy}$$

$$P\text{V} = n\text{R}T$$

$$n = \frac{P\text{V}}{\text{RT}}$$

$$n = \left(\frac{1.00 \text{ atm}}{1\text{ atm}}\right) \left(\frac{24.4\text{ L}}{24.4\text{ L}}\right)$$

$$\left(\frac{0.08206 \text{ L atm/mol K}}{1\text{ L atm/mol K}}\right) \left(273K\right)$$

$$n = 1.09 \text{ mol}$$

$$\text{?g H}_2\text{O} = \left(\frac{1.09\text{ mol H}_2}{2\text{ mol H}_2}\right) \left(\frac{18\text{ g/mol}}{2\text{ mol H}_2}\right)$$

$$\text{?g H}_2\text{O} = 19.6\text{ g H}_2\text{O}$$

18) A balloon used in class on the Monday before Thanksgiving contained mostly

- Ne
- H$_2$
- He
- N$_2$

19) Carbon dioxide changes from s$\rightarrow$g at 1 atm pressure and this is called
 deposition freezing sublimation condensation

20) The change from g$\rightarrow$l is called
 deposition freezing sublimation condensation

21) Circle all the molecular forces present between liquid water molecules.

hydrogen bonding dipole-dipole attraction van der Waals

22) Circle all the molecular forces present between liquid nitrogen molecules.

hydrogen bonding dipole-dipole attraction van der Waals
24) Which one of the following in solid form is an example of an ionic solid
   \[ \text{SiO}_2 \quad \text{CsCl} \quad \text{C}_2\text{H}_5\text{OH} \quad \text{Ti} \]

25) Which one of the following in solid form is the best conductor of electricity
   \[ \text{SiO}_2 \quad \text{CsCl} \quad \text{C}_2\text{H}_5\text{OH} \quad \text{Ti} \]

26) Which one of the following is made of molecules
   \[ \text{SiO}_2 \quad \text{CsCl} \quad \text{C}_2\text{H}_5\text{OH} \quad \text{Ti} \]

27) Which one of the following would conduct electricity as a liquid but not as a solid
   \[ \text{SiO}_2 \quad \text{CsCl} \quad \text{C}_2\text{H}_5\text{OH} \quad \text{Ti} \]

28) On the phase diagram for $\text{H}_2\text{O}$ below label the areas associated with solid, liquid, and gas

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\begin{center}
\begin{tikzpicture}
  \draw[->] (0,0) -- (5,0) node[anchor=north] {T (K)};
  \draw[->] (0,0) -- (0,5) node[anchor=east] {P (atm)};
  \draw (0,0) -- (2,4) -- (4,2) -- (0,0);
\end{tikzpicture}
\end{center}
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29) On the heating curve below, draw a circle around just the region that indicates where change from solid to liquid is occurring

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\begin{center}
\begin{tikzpicture}
  \draw[->] (0,0) -- (5,0) node[anchor=north] {time of heating or energy input};
  \draw[->] (0,0) -- (0,5) node[anchor=east] {Temp (atm)};
  \draw (0,0) -- (2,4) node[anchor=south] {melt} -- (4,2) node[anchor=north] {vaporize};
\end{tikzpicture}
\end{center}
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30) As you go to a higher elevation the air pressure gets lower because
   - less gravity
   - less weight of air above you
   - temperature increases
   - molecules are larger

31) Draw a picture of the meniscus for water in a glass tube clearly indicating the shape of the surface of the water.

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\begin{center}
\begin{tikzpicture}
  \draw[fill=white] (0,0) circle (0.5);
  \draw[thick] (-0.5,0) -- (0.5,0);
\end{tikzpicture}
\end{center}
```

32) What type of interaction causes the water to be strongly attracted to the glass?

   hydrogen bonding