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1.

Convert the following temperatures to the Kelvin scale:

278°C = _____K

-196°C = _____K

2.

To what temperature must a **2.0 L** container filled with **2.44 g** of Ne be heated to obtain a pressure of **1.80** atm? Express your answer to the nearest degree.
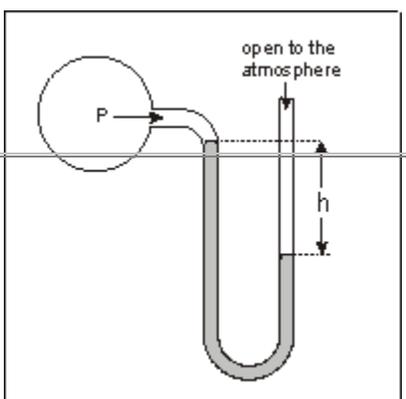_____K

3.

The following experiment is used to determine the amount of helium gas in the container. In the experiment

- V = 8.250 L
- h = 250 mm.
- t = 10° C
- P_{bar} = 752 torr.

Determine the pressure in atmospheres (P), the number of moles (n), and the mass (m) of the helium gas:

P = _____atm.

n = _____mol

	m =	_____g

4.

1.636 g He, 17.290 g F_2, and 14.200 g Ar are placed in a 11.0-L container at 23 °C. What are the molar concentrations and partial pressures of the gases?

gas	Molar concentration	Partial pressure
He	_____M	_____atm
F_2	_____M	_____atm
Ar	_____M	_____atm

What is the total pressure in the container?
P = _____atm

5.

What is the approximate thermal energy in kJ/mol of molecules at **275° C**?
Express your answer to the nearest 0.1 kJ/mol
_____kJ/mol
To what temperature must a substance be heated so that its thermal energy is about **5** kJ/mol? Express your answer to the nearest degree.
_____K

6.

Consider a balloon of nitrogen gas and a crystal of sugar sitting on a table at room conditions. Select the appropriate statement to fill in the blanks of each of the following. Note that there are only two parts but four questions. You must get both questions correct in a part to get credit for that part.

First part - comparing the same energy in different molecules

a) The thermal energy of the sugar molecules is _____ that of the nitrogen molecules.

    [_] greater than
    [_] about the same as
    [_] less than

b) The energy of interaction between sugar molecules is _____ that of the nitrogen molecules.

[_] greater than
[_] about the same as
[_] less than

Second part - comparing different energies in the same molecule

c) The thermal energy of the sugar molecules is _____ their energy of interaction.

[_] greater than
[_] about the same as
[_] less than

d) The thermal energy of the nitrogen molecules is _____ their energy of interaction.

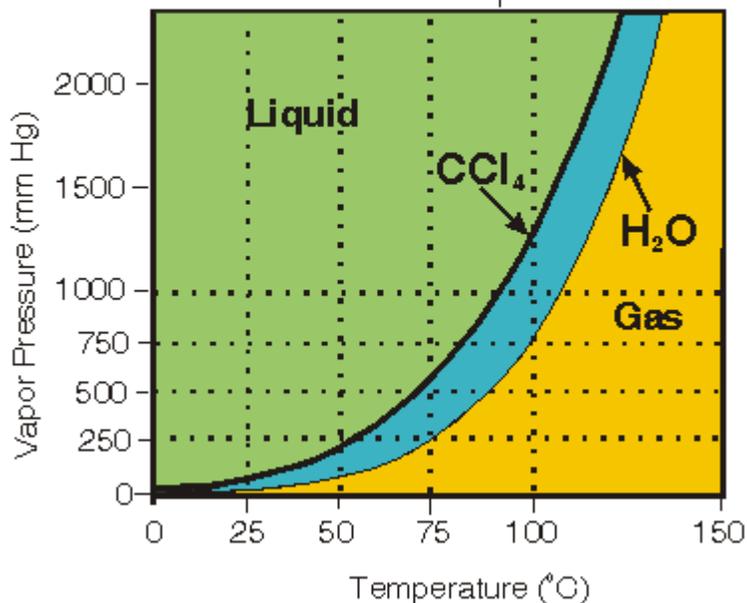[_] greater than
[_] about the same as
[_] less than

1.

Use the following diagram of the vapor pressures of CCl_4 and H_2O as a function of temperature to determine the states of CCl_4 and H_2O at the following conditions.
Use L = liquid and G = gas.

Vapor pressure of H_2O and CCl_4 as a function of temperature.

t (°C)	P (torr)	CCl₄ (L or G)	H₂O State
75	500		
100	500		
75	1000		

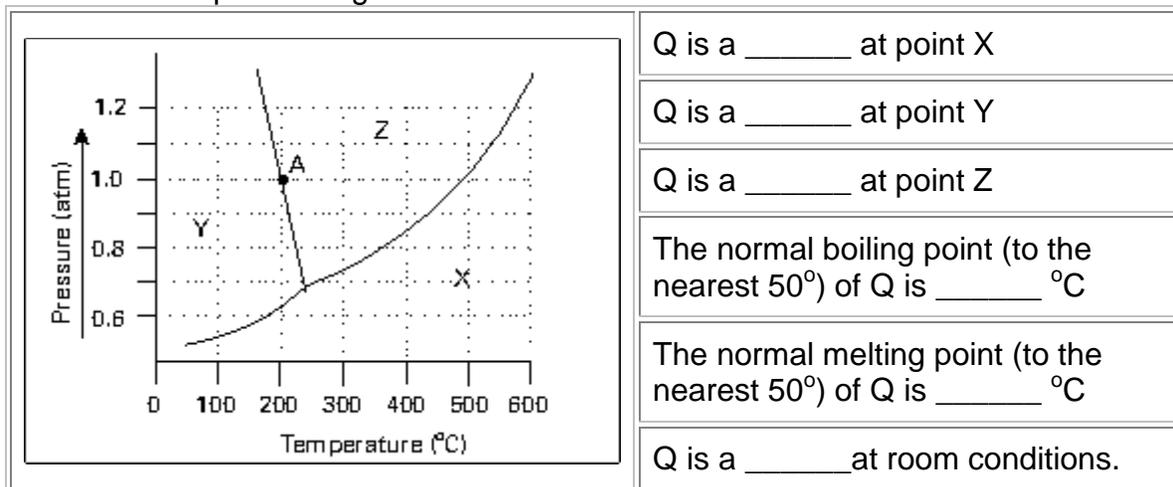What the approximate boiling point (to the nearest 10 °C) of CCl_4 at 500 torr?

t = _____ °C

What is the approximate vapor pressure (to the nearest 50 torr) of H_2O at 75 °C?

P = _____ torr

___

2.

Consider the phase diagram of substance Q shown below.

Q is a _____ at point X
Q is a _____ at point Y
Q is a _____ at point Z
The normal boiling point (to the nearest 50°) of Q is _____ °C
The normal melting point (to the nearest 50°) of Q is _____ °C
Q is a _____at room conditions.

	The vapor pressure of Q at 420 °C to the nearest 0.1 atm is _____ atm
	When Q is heated at point A, it _____
	When a pressure is applied to Q at point A it _____

3.

Forces between similar molecules are said to be _____ while those between different types of molecule are said to be _____. Water 'beads' due to its strong _____ forces. The meniscus of water in a glass tube is _____ because the _____ forces are strong.

4.

Use a table for the Vapor Pressure of Water to answer the following. Report temperatures to the nearest 5 °C and pressures to the nearest 0.1 torr.

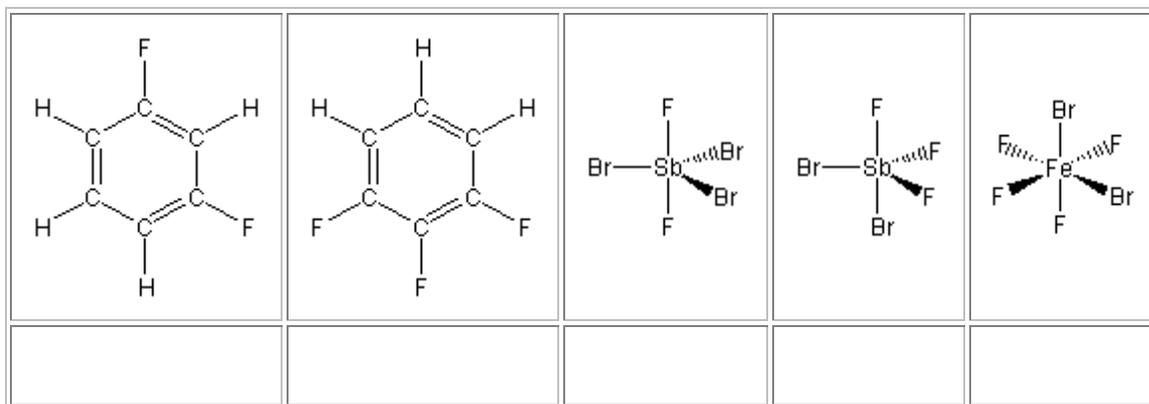a) What are the pressure of water and the dew point in a system in which the relative humidty is 34.4% at 50 °C?

Pressure of water =	_____ torr
Dew Point =	_____ °C

b) The pressure of water vapor in the atmosphere is found to be 31.8 when it is 35 °C. What are the dew point and relative humidty?
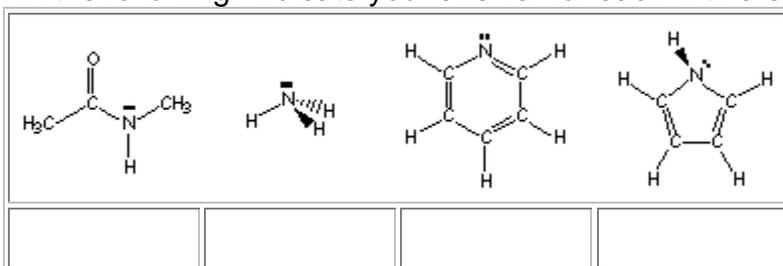
Dew Point =	_____ °C
Relative Humidity =	_____%

1.

Indicate whether each of the following molecules is polar (P) or nonpolar (N).

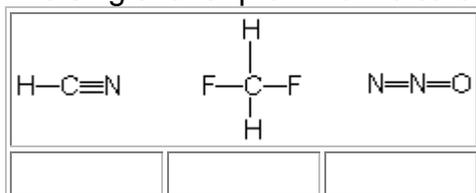|				

2.

Indicate whether hydrogen bonding between like molecules would be important in the following. Indicate your answer for each with a single letter (y or n),

---

3.

Indicate whether each of the following molecules is polar (p) or nonpolar (n). Use the single letter p or n to indicate the polarity.


4.

Indicate which molecule in each pair has the higher boiling point. Also indicate which force is responsible for the difference.

a	b	Molecule (a or b)	Force
NH_3	AsH_3		
C_2H_5OH	$(CH_3)_2O$		
$C_{10}H_{20}$	C_4H_8		
HF	HCl		

1.

A compound formed between calcium, titanium, and oxygen crystallizes in the *perovskite* structure shown below. Ca^{2+} cations (white circles) reside on the corners of the unit cell, the Ti^{4+} cation (black circle) resides in the body center of the cubic cell, and O^{2-} anions (gray circles) reside on each of the cell faces. What is the formula of the compound? Write the elements in the order Ca, Ti, O.

_____
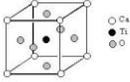
2.

The imaginary element X (M_m = 64.8 g/mol) crystallizes in a fcc unit cell that is 3.12 Å (1 Å = 1e-08 cm) on a side. Determine the following parameters.

atomic radius of X = _____Å

volume of one unit cell = _____cm^3

number of X atoms in one unit cell = _____

volume of atoms in one unit cell = _____cm^3

packing efficiency of crystal determined from these results to the nearest percent = _____ %.

total mass of atoms in one unit cell = _____ g

density of element X = _____ g/cm^3

3.

Use the figures to answer the questions under them. The blue and red spheres represent the same type of particles, but the blue and yellow particles are different.

CN of blue sphere				

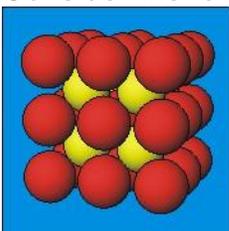| unit cell type				
fraction of blue sphere in uc				
number of particles in uc				

4.

Atom X crystallizes in a body-centered cubic unit cell that is 4.25 A on a side. What is the metallic radius of X?

r = _____ A

1.

Consider the following crystal structure:

How many unit cells are shown in the figure?
If red and yellow spheres are the same? _____
If red and yellow spheres are different? _____
What is the coordination number of the yellow sphere?
CN = _____
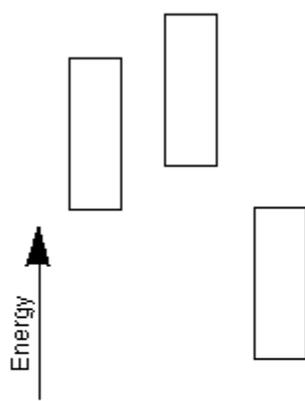What is the unit cell type?
If red and yellow spheres are the same? _____
If red and yellow spheres are different? _____

2.

Materials A, B, and C have the following band strctures. One is a conductor, on a semiconductor, and an insulator. Identify each.

A: _____

B: _____

Energy

C: _____

3.

Indicate the substance in each pair (A or B) with the higher melting point.

A	B	A or B
SrO	AlN	
CaF_2	CS_2	
SO_2	SiO_2	

4.
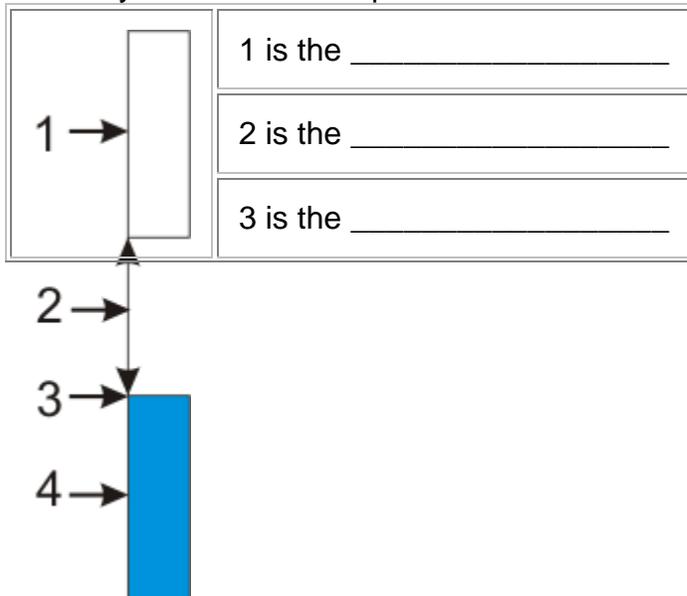
Indicate whether the solid state of each of the following is network covalent, ionic, metallic, or molecular.

Zn	_____
C	_____
GaAs	_____
ZnS	_____
NH_4Br	_____

5.

Identify the four labeled positions in the following diagram:

1 is the _____

2 is the _____

3 is the _____

1→

2→

3→

4→

	4 is the _____

6.

Match the following descriptions with the material.

porous material used as molecular sieves and in ion exchange	
form of carbon that was the object of extensive research but produced no new uses	
layered structure material that is an excellent lubricant	
layered structure material found in porcelin	
semiconductor with same basic structure as diamond	

7.

Determine the distances below to the nearest 0.01 A from the following information.

- There are two nearest neighbor X atom distances in crystalline X_2: 1.42 A and 2.84 A.
- The shortest X-Y distance in crystalline XY_2 is 2.16 A.

covalent radius of X = _____A

van der Waals radius of X = _____A

covalent radius of Y = _____ A

1.

What are ΔE, ΔE_{sur} and ΔE_{univ} if **335 J** of work are done by a system while it absorbs **150 J** of heat.

ΔE: _____J
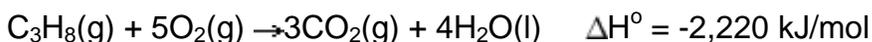
ΔE_{sur}: _____J

ΔE_{univ}: _____J

2.

Consider the combustion of propane gas,

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$ $\Delta H^\circ = -2{,}220$ kJ/mol

Propane is often used for gas grills and is typically purchased by filling a propane tank with 20 pounds of propane. How much heat can be obtained by burning 15 pound of propane? Use the conversion 1 lb = 454 g and express your answer in scientific notation. For example use 2.3e-5 to indicate a number such as 2.3×10^{-5}.

_____kJ

What is the **enthalpy change** for

$9\ CO_2(g) + 12\ H_2O(l) \rightarrow 3\ C_3H_8(g) + 15\ O_2(g)$
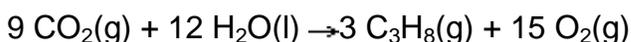
Hint, compare this equation to the combustion equation for propane.

_____kJ

3.
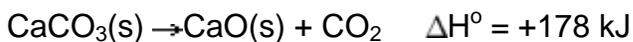
Use a table of bond energies to estimate the **enthalpy change** in each of the following reactions:

Reaction	ΔH (kJ)
$H_2CBr_2(g) + F_2(g) \rightarrow H_2CF_2(g) + Br_2(g)$	
$ICH_3(g) + H_2O(g) \rightarrow H_3COH(g) + HI(g)$	
$HC{\equiv}CH(g) + 2H_2(g) \rightarrow H_3C\text{-}CH_3(g)$	
$CH_4(g) \rightarrow C(g) + 2H_2(g)$	

4.

Consider the following thermochemical equation:

$CaCO_3(s) \rightarrow CaO(s) + CO_2$ $\Delta H^\circ = +178$ kJ

How much heat must be absorbed by 34.5 g of $CaCO_3$ to convert it completely to CaO?

_____kJ

1.

Indicate whether ΔS^0 is large and positive, large and negative, or nearly zero in each of the following reactions:

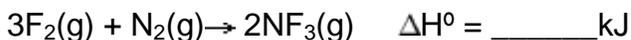| Reaction	ΔS^0
$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$	
$HF(aq) + NO_2^{1-}(aq) \rightarrow F^{1-}(aq) + HNO_2(aq)$	
$N_2(g) + 2H_2(g) \rightarrow N_2H_4(g)$	
$NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$	

2.

Indicate the sign of ΔG^0 at low and high temperatures for the following reactions:

Reaction	Low T	High T
$NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$ $\Delta H^0 < 0$		
$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ $\Delta H^0 > 0$		
$CH_3OH(l) \rightarrow CH_3OH(g)$		
$2Cl_2(g) + 7O_2(g) \rightarrow 2Cl_2O_7(l)$ $\Delta H^0 > 0$		

3.

Use the Table of Bond Energies to estimate the value of ΔH^0 at 298 K for the following reaction:

$3F_2(g) + N_2(g) \rightarrow 2NF_3(g)$ $\Delta H^0 = $ _____kJ

ΔS^0 is expected to be _____.

The reaction would be extensive at _____.

4.

Consider the reaction $C_2H_4(g) + HCl(g) \rightarrow C_2H_5Cl(g)$.

Use bond energies to estimate the value of **ΔH^0 at 298 K**.
_____kJ

ΔS^0 is expected to be _____.

The reaction would be extensive at _____.

1.
Determine the value of the equilibrium constant (report your answer to three significant figures) for the following reaction if an equilibrium mixture contains 0.010 mol of solid $PbBr_2$, and is 0.0100 M in Pb^{2+} ions and 0.0250 M in Br^{1-} ions. Use the notation 4.31e-5 to indicate a number such as 4.31 x 10^{-5}.

$PbBr_2(s) \rightleftharpoons Pb^{2+}(aq) + 2Br^{1-}(aq)$ K = _____
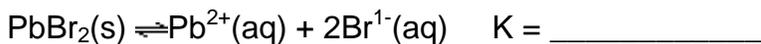
2.
The following equilbrium partial pressures were measured at some temperature

NH_3	N_2	H_2
0.330 atm	0.190 atm	0.250 atm

Determine the value of the equilibrium constant for the following reaction at the temperature.
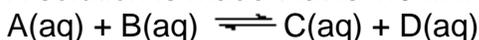$N_2 + 3H_2 \rightleftharpoons 2NH_3$

K = _____

In a different experiment at the same temperture, the equilibrium pressure of N_2 was found to be 0.300atm and that of H_2 to be 0.340 atm. What is the equilibrium pressure NH_3 if K = 5.220 for the above reaction at the temperature of the equilibrium?
$P(NH_3)$ = _____ atm

3.

A solution is made that is 1.0 M in A and 1.0 M in B. A and B then react:
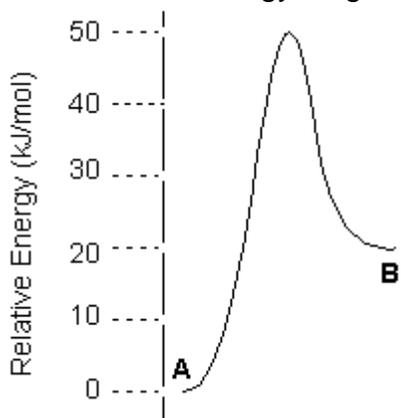$A(aq) + B(aq) \rightleftharpoons C(aq) + D(aq)$
What would the equilibrium concentration of A be with each of the following equilibrium constants? Note that ~0 means that the concentration is very small.

K	[A]

10^8	
1	
10^{-8}	

4.

Consider the energy diagram for the reaction A(g)→ B(g)

ΔE for A(g) →B(g)	_____kJ/mol
The activation energy for A(g) →B(g)	_____kJ/mol
The activation energy for B(g) →A(g)	_____ kJ/mol

Fill-in the following blanks.
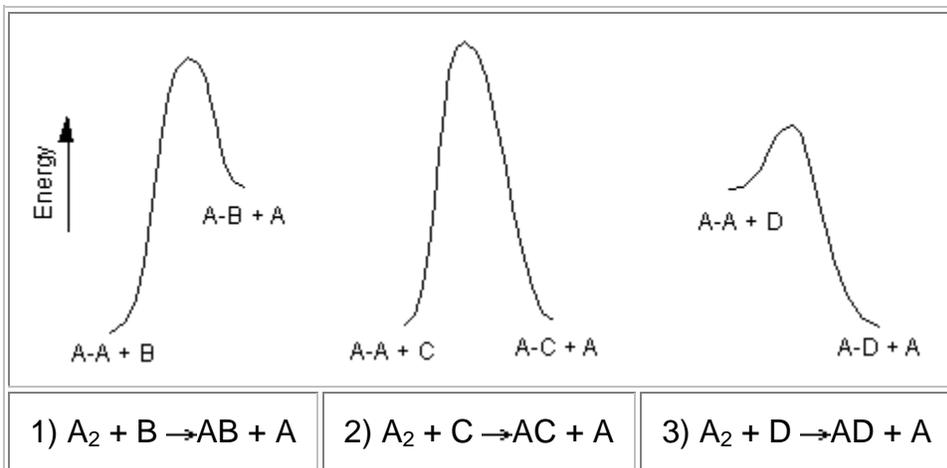
The forward rate constant is _____ the reverse rate constant.

The amount of B at equilibrium _____ as the temperature increases.

The forward reaction is probably _____.

Compare the reaction energy diagrams for the three gas phase reactions shown below

1) $A_2 + B \rightarrow AB + A$	2) $A_2 + C \rightarrow AC + A$	3) $A_2 + D \rightarrow AD + A$

Assume that steric factors are all comparable and that entropy is not important in the following. Specify a reaction with its number (1,2, or 3).
The reaction with the largest rate constant is _____

The reaction with largest equilibrium constant is _____

The reaction whose equilibrium constant increases the most with an increase in temperature is _____

The strongest bond is the _____ bond.

The weakest bond is the _____ bond.

Consider the following equilibrium:

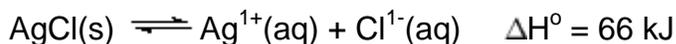$A + B \rightleftharpoons C + D + E \qquad \Delta H^o > 0$

Use LeChatelier's principle to predict the effect on the concentration of the equilibrium concentration of E caused by each of the following actions:

action	result on [E]
adding A	
removing B	

increasing the temperature	

7.

Consider the following equilibrium:

$$AgCl(s) \rightleftharpoons Ag^{1+}(aq) + Cl^{1-}(aq) \quad \Delta H° = 66 \text{ kJ}$$

Use LeChatelier's principle to predict the effect on the chloride ion concentration caused by each of the following actions:

Action	Effect on $[Cl^{1-}]$
adding silver chloride	
adding silver ion	
adding water	
heating	

8.

The reaction A + 2B →3C occurs in one step. In each blank below, write the exponent of the concentration in the rate law or write none if that concentration does not appear in the rate law.

[A] _____

[B] _____

[C] _____

1.

What is the total concentration of all ions (the sum of their individual concentrations) in aqueous solutions of the following?

- Hint: Each substance is an electrolyte that dissociates in water to produce ions. Use a table of polyatomic ions if you do not recognize the polyatomic ion. For example, $Na_2SO_4 \rightarrow 2Na^{1+} + SO_4^{2-}$ when it dissolves, so a 1 M soln of Na_2SO_4 is 2M in Na^{1+} and 1M in SO_4^{2-} and the total concentration of ions is 2 M + 1 M = 3M.

0.0440-M $CaCl_2$	_____M

0.0600-M Na$_3$PO$_4$	_____M
0.0580-M K$_2$Cr$_2$O$_7$	_____M

2.

What mass of Al$_2$(SO$_4$)$_3$ is required to make 51 mL of a 0.070-M solution of Al$_2$(SO$_4$)$_3$?

_____ g Al$_2$(SO$_4$)$_3$

How many **moles** of **aluminum** ions are present in the solution?

_____ mol

3.

Indicate whether each of the following would be more soluble in hexane (C$_6$H$_{14}$) or water.

Substance	More soluble in
KI	
C$_8$H$_{18}$	
CH$_3$(CH$_2$)$_{12}$OH	
CH$_3$OH	

4.

Indicate whether each of the following is a strong electrolyte.

KF	
CH$_3$Cl	
H$_2$O	
NaOH	
CH$_3$COONa	
NH$_4$Cl	

1.

Use the Solubility Rules to determine which of the following substances could be used to make a solution that is 0.1 M in Pb^{2+} ion. Select all that apply.

        [_] $PbCO_3$
        [_] $Pb(NO_3)_2$
        [_] $PbCrO_4$
        [_] $Pb(ClO_4)_2$
        [_] PbS
        [_] $PbCl_2$

2.

Indicate all of the following substances that could be used to make a solution that is 0.1 M in SO_4^{2-} ion.

Solubility Rules

        [_] K_2SO_4
        [_] $CuSO_4$
        [_] $BaSO_4$
        [_] $FeSO_4$
        [_] $PbSO_4$

3.

Write the formulas of the precipitates that would form when the following solutions are mixed, or write **none** if no precipitate would be produced. The answer are case sensitive. Do nothing to indicate subscripts. For example Na_2SO_4 would be Na2SO4.

Solubility Rules

lead acetate + potassium hydroxide	
sodium chromate + nickel(II) iodide	
strontium perchlorate + iron(II) sulfate	
ammonium acetate + cadmium nitrate	
thallium(I) nitrate + calcium chloride	
sodium sulfide + iron(III)chloride	

4.

Which of the following ions is present in the solution if a precipitate was observed with the addition of Ba^{2+} but no precipitate was observed with the addition of Ag^{1+}?

- (_) SO_4^{2-}
- (_) ClO_4^{1-}
- (_) NO_3^{1-}
- (_) Cl^{1-}
- (_) CrO_4^{2-}

Which of the following cations is present if a precipitate was observed with the addition of SO_4^{2-} but not with the addition of Cl^{1-}?

- (_) Cu^{2+}
- (_) K^{1+}
- (_) Pb^{2+}
- (_) Ag^{1+}
- (_) Sr^{2+}

Which of the following hydroxides is predicted to be the least soluble in water?

- (_) $Fe(OH)_2$
- (_) $Al(OH)_3$
- (_) KOH
- (_) $Ca(OH)_2$
- (_) $TlOH$

5.

Use the Solubility Rules to write **net ionic equations** for the reactions that occur when solutions of the following are mixed.

Instructions

1. Write reactants and products in the following order:
   Cation + Anion -> Precipitate
2. Use "->" (hyphen + greater than) to indicate 'yields'
3. Write subscripts as numbers with no special character, but use a "^" before each superscript. Always write the number before the sign and always include '1'. Thus, HCO_3^{1-} would be HCO3^1-.
4. Answers are case sensitive. Spaces are ignored, so insert them as you wish for readability.
5. Click on the "eye" symbol to see your formatted response.

Use all lower case letters to write none if no reaction occurs.

        Reactants   **Cation + Anion -> Precipitate or none**

a) K_2S + $ZnSO_4$

b) K_2CrO_4 + $NiCl_2$

c) $CsOH$ + $FeCl_3$

d) $CuSO_4$ + $Pb(ClO_4)_2$

e) $FeSO_4$ + K_3PO_4

f) $FeCl_2$ + $TlNO_3$

g) $(NH_4)_2CO_3$ + $Ca(ClO_4)_2$