Name: _____ Date: _____

AP Chemistry Holiday Fun Questions

Please complete all questions on lined paper. Show all work, including units and correct significant figures. These questions will be due on January 9th at 8:30 AM. A select set of questions will be marked, but all questions must be completed to get credit for this assignment.

1. Mass spectroscopy is an analysis technique used to determine the masses of particles within a sample. It can be used to determine the composition of a substance by determining the empirical formula or the abundance of isotopes. There are two different isotopes of bromine atoms, "A" and "B". Under normal conditions, bromine forms a diatomic molecule and the mass of the molecule is the sum of the two atoms. The mass spectrum of Br_2 shows three peaks:

Peak	Mass (amu)	Abundance
1	157.836	25.70%
2	159.834	49.99%
3	161.832	24.31%

   a. Determine the average molecular mass of a Br_2 molecule and the average atomic mass of a bromine atom.
   b. Calculate the percent abundance of each isotope, using correct isotopic notation.
2. There are two different isotopes of chlorine atoms, "A" and "B". Under normal conditions, chlorine forms a diatomic molecule and the mass of the molecule is the sum of the two atoms. The mass spectrum of Cl_2 shows three peaks:

Peak	Mass (amu)	Abundance
1	69.938	67.70%
2	71.938	16.15%
3	73.938	16.14%

   a. Determine the mass of each isotope of chlorine.
   b. Use the percent abundance of each chlorine isotope to determine the average atomic mass of chlorine.
3. An oxybromate compound, $KBrO_x$, where x is unknown, is analyzed and found to contain 52.92% Br by mass. Determine the atomic mass of the compound.
4. Indigo, the dye for blue jeans, ha a percent composition by mass of 73.27% C, 3.84% H, 10.68% N and the remainder as oxygen. Its molar mass is 262.3 g/mol. What is the molecular formula of indigo?
5. When hydrocarbons are burned in a limited amount of air, both CO and CO_2 form. When 0.450 g of a hydrocarbon was burned in air, 0.467 g of CO, 0.733 g of CO_2 and 0.450 g of H_2O were formed. The molar mass of the compound is 54.10 g/mol. Determine the molecular formula of the compound.
6. A 3.455-g sample of a mixture was analyzed for barium ion by adding a small excess of sulfuric acid to an aqueous solution of the sample. The resultant reaction produced a precipitate of barium sulfate with a mass of 0.2815 g. What is the mass percentage of barium in the sample?
7. How many grams of commercial acetic acid (97% $HC_2H_3O_2$ by mass) must be allowed to react with an excess of PCl_3 to produce 75 g of acetyl chloride (C_2H_3OCl) if the reaction has a 58.9% yield? The other product is H_3PO_3.
8. A sample of 5.33 g of $Mg(OH)_2$ is added to 25.0 mL of 0.200 M HNO_3. Determine the number of moles of each of the reactants remaining after the reaction.
9. Cyanogen, a highly toxic gas, is composed of 46.2% C and 53.8% N by mass. At 25°C and 751 torr, 1.05 g of cyanogen occupies 0.500 L.
   a. What is the molecular formula of cyanogen?
   b. Use formal charge to predict the Lewis structure of cyanogen.
10. An herbicide is found to contain only C, H, N and Cl. The complete combustion of a 100.0-mg sample of the herbicide in excess oxygen produces 83.16 mL of CO_2 and 73.30 mL of H_2O vapour at STP. A separate analysis shows that the sample also contains 16.44 mg of Cl.
   a. Determine the percent composition of the substance.
   b. Calculate its empirical formula.

11. Determine the enthalpy of the target equation using Hess' Law.

Target	**$HCl\,(g) + NaNO_2\,(s) \rightarrow HNO_2\,(l) + NaCl\,(s)$**	**ΔH = ?**
1	$2NaCl\,(s) + H_2O\,(l) \rightarrow 2HCl\,(g) + Na_2O\,(s)$	ΔH = 507 kJ
2	$NO\,(g) + NO_2\,(g) + Na_2O\,(s) \rightarrow 2NaNO_2\,(s)$	ΔH = -427 kJ
3	$NO\,(g) + NO_2\,(g) \rightarrow N_2O\,(g) + O_2\,(g)$	ΔH = -43 kJ
4	$2HNO_2\,(l) \rightarrow N_2O\,(g) + O_2\,(g) + H_2O\,(l)$	ΔH = 34 kJ

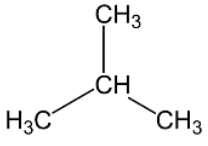
12. Determine the enthalpy of the target equation using Hess' Law.

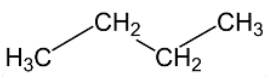
Target	**$\frac{1}{2} H_2\,(g) + \frac{1}{2} Cl_2\,(g) \rightarrow HCl\,(g)$**	**ΔH = ?**
1	$COCl_2\,(g) + H_2O\,(l) \rightarrow CH_2Cl_2\,(l) + O_2\,(g)$	ΔH = 47.5kJ
2	$2HCl\,(g) + \frac{1}{2} O_2\,(g) \rightarrow H_2O\,(l) + Cl_2\,(g)$	ΔH = 105 kJ
3	$CH_2Cl_2\,(l) + H_2\,(g) + \frac{3}{2}O_2\,(g) \rightarrow COCl_2\,(g) + 2H_2O\,(l)$	ΔH = -402.5 kJ

13. In a coffee cup calorimeter, 100.0 mL of 1.0 M NaOH and 100.0 mL of 1.0 M HCl are mixed. Both solutions were originally at 24.6°C. After the reaction, the final temperature is 31.3°C. Assuming that all solutions have a density of 1.0 g/cm^3 and a specific heat capacity of 4.184 J/g·°C, calculate the enthalpy change for the neutralization of HCl by NaOH. Assume that no heat is lost to the surroundings or the calorimeter.
14. A sample of a gaseous carbon-hydrogen-oxygen compound that occupies a volume of 582 mL at 765.5 Torr and 25.00°C is burned in an excess of O_2 (g) in a bomb calorimeter. The combustion reaction is raises the temperature of the calorimeter assembly from 25.00 to 31.94°C. The heat capacity of the calorimeter is 5.015 kJ/°C. Determine $\Delta H°$ for this reaction at 25.00°C.
15. The reaction of indium with sulfur leads to three binary compounds, which we will assume to be purely ionic. The three compounds have the following properties:

Compound	Mass % Indium	Melting Point (°C)
A	87.7	653
B	78.2	692
C	70.5	1050

    a. Determine the empirical formula of each compound.
    b. Write the electron configuration for the indium ion in each compound:
    c. In which compound would the ionic radius of indium be the smallest? Why?
    d. Explain which compound would have the highest lattice energy.
16. The molecules SiF_4, SF_4 and XeF_4 have molecular formulas of the type AF_4, but the molecules have different molecular geometries.
    a. Draw the Lewis structure for each molecule.
    b. What is the molecular geometry of each molecule?
    c. Which of these molecules are polar? Explain why.
17. Consider the molecules SO_2, SO_3 and SF_6:
    a. Draw the Lewis structure for each molecule, including resonance structures when needed.
    b. What is the molecular geometry of each molecule?
    c. Which of these molecules are polar? Explain why.
18. For each pair of substances, identify which has a higher boiling point. Justify your answer.

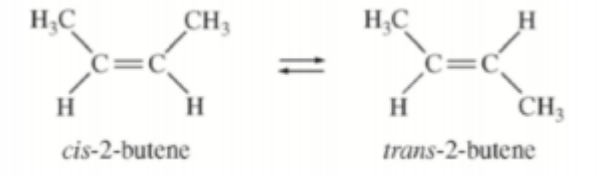




    a.
    b. $CCHBr_3$, $CHCl_3$
    c. Br_2, ICl

19. The half-life ($t_{1/2}$) of the catalyzed isomerization of *cis*-2-butene gas to produce *tran*-2-butene gas was measured under various conditions, as shown in the table below:

Trial Number	Initial $P_{cis\text{-}2\text{-butene}}$ (torr)	V (L)	T (K)	$T_{1/2}$ (s)
1	300.	2.00	350.	100.
2	600.	2.00	350.	100.
3	300.	4.00	350.	100.
4	300.	2.00	365	50.



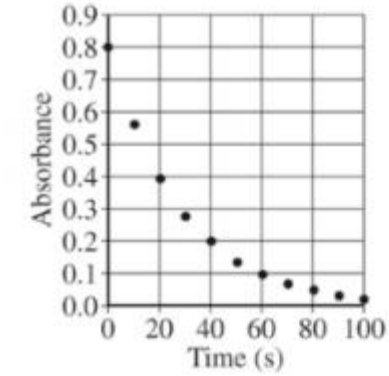
cis-2-butene *trans*-2-butene

a. Calculate the rate constant for the reaction at 350 K, including units, considering this is a first order reaction.
b. Would you expect the initial rate in trial 1 to be higher, lower or the same as trial 3? Explain why.
c. The half-life of the reaction in trial 4 is less than in trial 1. Explain why.

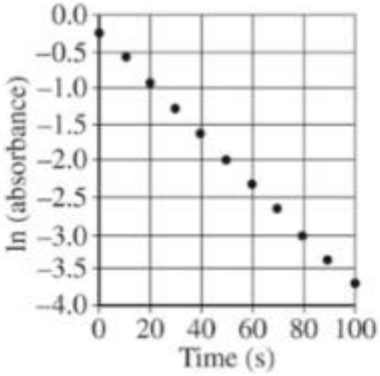
20. Blue food colouring can be oxidized by household bleach, which contains OCl^-, to form colourless products represented by the equation:

$$Na_2C_{27}H_{34}N_2S_3O_9 + OCl^- \rightarrow \text{products}$$
blue *colourless*

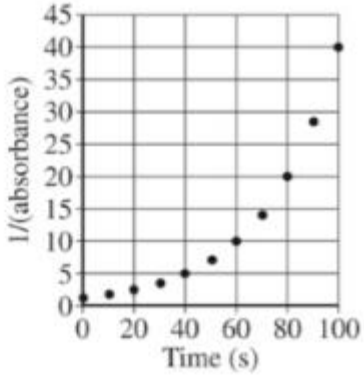
A student used a spectrophotometer set at a wavelength of 635 nm to study the absorbance of the food colouring over time during the bleaching process. In the study, bleach is present in a large excess so that the concentration of OCl^- is essentially constant throughout the reaction. A student used data from the study to generate these graphs:



Graph I



Graph II



Graph III

a. What is the order of the reaction with respect to the blue food colouring? Write the rate law
b. The reaction is known to be first order with respect to bleach. In a second experiment, the student prepares solutions of food colouring and bleach with concentrations that differ from those used in the first experiment. When the solutions are combined, the student observes that the reaction mixture reaches an absorbance near zero too rapidly. To correct the problem, indicate and explain which of the following modifications would increase the reaction time:
    i. Increase temperature
    ii. Increase food colouring concentration
    iii. Increase bleach concentration
c. In another experiment, a student wishes to study the oxidation of blue food colouring with bleach. How does the student need to modify the original procedure?

21. An equilibrium mixture of H_2, I_2 an HI at 458°C contains 0.112 mol H_2, 0.113 mol I_2 and 0.775 mol HI in a 5.00-L vessel.
    a. What is K_p for this system?
    b. After equilibrium is established, 0.100 mol of HI is added to the system. What are the new equilibrium partial pressures of the gases?
    c. If the volume of this system is decreased, which way will the reaction shift?
22. Write the equilibrium constant expression for the equilibrium:

$$C\ (s) + CO_2 \rightleftharpoons 2\ CO\ (g)$$

The table included below shows the relative mole percentages of CO_2 (g) and CO (g) at a total pressure of 2.50 atm for several temperatures.

Temperature (°C)	**CO_2 (mol %)**	**CO (mol %)**
850	6.23	93.77
950	1.32	98.68
1050	0.37	99.63
1200	0.06	99.94

    a. Calculate the value of K_p at each temperature.
    b. Explain whether this reaction is endothermic or exothermic.
    c. If the volume of this system is decreased, which way will the reaction shift?