

A. Warmup:**Question 1 – 5**

- (A) CO_2
 - (B) H_2O
 - (C) BF_3
 - (D) NH_3
 - (E) CH_4
1. Has a bond angle of 109.5° .
 2. This is a polar molecule that is bent.
 3. This is a tetrahedral molecule.
 4. Linear and non-polar
 5. Planar and symmetrical.

Question 6 – 10

- (A) Covalent Network
 - (B) Ionic Bonding
 - (C) Metallic Bonding
 - (D) Molecular Bonding
 - (E) Hydrogen Bonding
6. Delocalized electrons
 7. Generally will have the highest melting point
 8. A lattice structure made up of cations and anions
 9. Sometimes described as a “sea of electrons”
 10. Will produce electricity when dissolved in water

B. Mixed MC Practice (NO CALCULATORS)

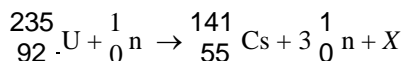
11. A flask contains 0.25 mole of $\text{SO}_2(g)$, 0.50 mole of $\text{CH}_4(g)$, and 0.50 mole of $\text{O}_2(g)$. The total pressure of the gases in the flask is 800 mm Hg. What is the partial pressure of the $\text{SO}_2(g)$ in the flask?
- (A) 800 mm Hg (B) 600 mm Hg (C) 250 mm Hg (D) 200 mm Hg (E) 160 mm Hg



In liquid ammonia, the reaction represented above occurs. In the reaction NH_4^+ acts as

- (A) a catalyst (B) both an acid and a base
(C) the conjugate acid of NH_3 (D) the reducing agent
(E) the oxidizing agent

13.



Neutron bombardment of uranium can induce the reaction represented above. Nuclide X is which of the following?

- (A) ${}_{35}^{92}\text{Br}$ (B) ${}_{35}^{94}\text{Br}$ (C) ${}_{37}^{91}\text{Rb}$ (D) ${}_{37}^{92}\text{Rb}$ (E) ${}_{37}^{94}\text{Rb}$

14. A compound contains 1.10 mol of K, 0.55 mol of Te, and 1.65 mol of O. What is the simplest formula of this compound?

- (A) KTeO (B) KTe_2O (C) K_2TeO_3 (D) K_2TeO_6 (E) K_4TeO_6

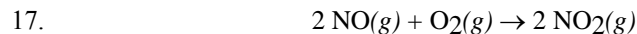


What is the standard enthalpy change, ΔH° , for the reaction represented above? (ΔH°_f of $\text{C}_2\text{H}_2(g)$ is 230 kJ mol^{-1} ; ΔH°_f of $\text{C}_6\text{H}_6(g)$ is 83 kJ mol^{-1} .)

- (A) -607 kJ (B) -147 kJ (C) -19 kJ (D) $+19 \text{ kJ}$ (E) $+773 \text{ kJ}$

16. Approximately what mass of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ (250 g mol^{-1}) is required to prepare 250 mL of 0.10 M copper (II) sulfate solution?

- (A) 4.0 g (B) 6.2 g (C) 34 g (D) 85 g (E) 140 g



A possible mechanism for the overall reaction represented above is the following.

- (1) $\text{NO}(g) + \text{NO}(g) \rightarrow \text{N}_2\text{O}_2(g)$ slow
(2) $\text{N}_2\text{O}_2(g) + \text{O}_2(g) \rightarrow 2 \text{NO}_2(g)$ fast

Which of the following rate expressions agrees best with this possible mechanism?

- (A) $\text{Rate} = k[\text{NO}]^2$ (B) $\text{Rate} = k \frac{[\text{NO}]}{[\text{O}_2]}$ (C) $\text{Rate} = k \frac{[\text{NO}]^2}{[\text{O}_2]}$
(D) $\text{Rate} = k[\text{NO}]^2[\text{O}_2]$ (E) $\text{Rate} = k[\text{N}_2\text{O}_2][\text{O}_2]$

18. Of the following compounds, which is the most ionic?

- (A) SiCl_4 (B) BrCl (C) PCl_3 (D) Cl_2O (E) CaCl_2

19. The best explanation for the fact that diamond is extremely hard is that diamond crystals

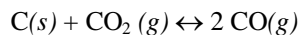
- (A) are made up of atoms that are intrinsically hard because of their electronic structures
 (B) consist of positive and negative ions that are strongly attracted to each other
 (C) are giant molecules in which each atom forms strong covalent bonds with all of its neighboring atoms
 (D) are formed under extreme conditions of temperature and pressure
 (E) contain orbitals or bands of delocalized electrons that belong not to single atoms but to each crystal as a whole

20. At 25°C aqueous solutions with a pH of 8 have a hydroxide ion concentration, $[\text{OH}^-]$, of

- (A) $1 \times 10^{-14} \text{ M}$ (B) $1 \times 10^{-8} \text{ M}$ (C) $1 \times 10^{-6} \text{ M}$ (D) 1 M (E) 8 M

D. Mixed FR Practice

Calculators allowed: 2008 A



1. Solid carbon and carbon dioxide gas at 1,160 K were placed in a rigid 2.00 L container, and the reaction represented above occurred. As the reaction proceeded, the total pressure in the container was monitored. When equilibrium was reached, there was still some $\text{C}(s)$ remaining in the container. Results are recorded in the table below.

Time (hours)	Total Pressure of Gases in Container at 1,160 K (atm)
0.0	5.00
2.0	6.26
4.0	7.09
6.0	7.75
8.0	8.37
10.0	8.37

- (a) Write the expression for the equilibrium constant, K_p , for the reaction.
- (b) Calculate the number of moles of $\text{CO}_2(g)$ initially placed in the container. (Assume that the volume of the solid carbon is negligible.)

- (c) For the reaction mixture at equilibrium at 1,160 K, the partial pressure of the $\text{CO}_2(g)$ is 1.63 atm. Calculate
- (i) the partial pressure of $\text{CO}(g)$, and
 - (ii) the value of the equilibrium constant, K_p
- (d) If a suitable solid catalyst were placed in the reaction vessel, would the final total pressure of the gases at equilibrium be greater than, less than, or equal to the final total pressure of the gases at equilibrium without the catalyst? Justify your answer. (Assume that the volume of the solid catalyst is negligible.)

In another experiment involving the same reaction, a rigid 2.00 L container initially contains 10.0 g of $\text{C}(s)$, plus $\text{CO}(g)$ and $\text{CO}_2(g)$, each at a partial pressure of 2.00 atm at 1,160 K.

- (e) Predict whether the partial pressure of $\text{CO}_2(g)$ will increase, decrease, or remain the same as this system approaches equilibrium. Justify your prediction with a calculation.

Calculators allowed: **2011 A**

2. A student is assigned the task of determining the mass percent of silver in an alloy of copper and silver by dissolving a sample of the alloy in excess nitric acid and then precipitating the silver as AgCl .

First the student prepares 50. mL of 6 M HNO_3 .

- (a) The student is provided with a stock solution of 16 M HNO_3 , two 100 mL graduated cylinders that can be read to ± 1 mL, a 100 mL beaker that can be read to ± 10 mL, safety goggles, rubber gloves, a glass stirring rod, a dropper, and distilled H_2O .
- (i) Calculate the volume, in mL, of 16 M HNO_3 that the student should use for preparing 50. mL of 6 M HNO_3 .
 - (ii) Briefly list the steps of an appropriate and safe procedure for preparing the 50. mL of 6 M HNO_3 . Only materials selected from those provided to the student (listed above) may be used.

- (iii) Explain why it is not necessary to use a volumetric flask (calibrated to $50.00 \text{ mL} \pm 0.05 \text{ mL}$) to perform the dilution.
- (iv) During the preparation of the solution, the student accidentally spills about 1 mL of 16 M HNO_3 on the bench top. The student finds three bottles containing liquids sitting near the spill: a bottle of distilled water, a bottle of 5 percent $\text{NaHCO}_3(aq)$, and a bottle of saturated $\text{NaCl}(aq)$. Which of the liquids is best to use in cleaning up the spill? Justify your choice.

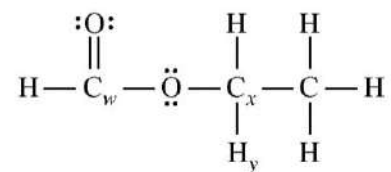
Then the student pours 25 mL of the 6 M HNO_3 into a beaker and adds a 0.6489 g sample of the alloy. After the sample completely reacts with the acid, some saturated $\text{NaCl}(aq)$ is added to the beaker, resulting in the formation of an AgCl precipitate. Additional $\text{NaCl}(aq)$ is added until no more precipitate is observed to form. The precipitate is filtered, washed, dried, and weighed to constant mass in a filter crucible. The data are shown in the table below.

Mass of sample of copper-silver alloy	0.6489 g
Mass of dry filter crucible	28.7210 g
Mass of filter crucible and precipitate (first weighing)	29.3587 g
Mass of filter crucible and precipitate (second weighing)	29.2599 g
Mass of filter crucible and precipitate (third weighing)	29.2598 g

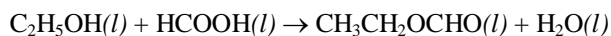
- (b) Calculate the number of moles of AgCl precipitate collected.
- (c) Calculate the mass percent of silver in the alloy of copper and silver.

No calculators: 2011 B form B

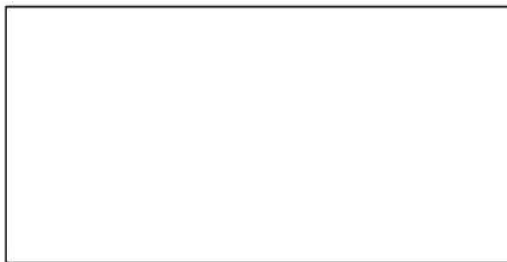
6. Use principles of molecular structure, intermolecular forces, and kinetic molecular theory to answer the following questions.
- (a) A complete Lewis electron-dot diagram of a molecule of ethyl methanoate is given below.



- (i) Identify the hybridization of the valence electrons of the carbon atom labeled C_w .
- (ii) Estimate the numerical value of the $H_y - C_x - O$ bond angle in an ethyl methanoate molecule. Explain the basis of your estimate.
- (b) Ethyl methanoate, CH_3CH_2OCHO , is synthesized in the laboratory from ethanol, C_2H_5OH , and methanoic acid, $HCOOH$, as represented by the following equation.

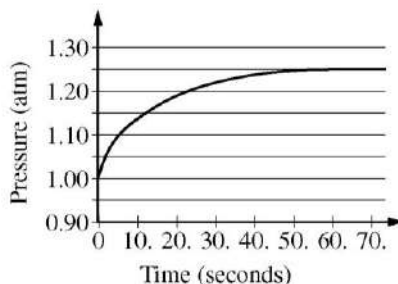


- (i) ~~In the box below~~, draw the complete Lewis electron-dot diagram of a methanoic acid molecule.
- (ii) In the box below, draw the complete Lewis electron-dot diagrams of a methanoic acid molecule and a water molecule in an orientation that allows a hydrogen bond to form between them.



Hydrogen Bonding Between Methanoic Acid and Water

- (c) A small amount of liquid ethyl methanoate (boiling point 54°C) was placed in a rigid closed 2.0 L container containing argon gas at an initial pressure of 1.00 atm and a temperature of 20°C . The pressure in the container was monitored for 70. seconds after the ethyl methanoate was added, and the data in the graph below were obtained. It was observed that some liquid ethyl methanoate remained in the flask after 70. seconds. (Assume that the volume of the remaining liquid is negligible compared to the total volume of the container.)



- (i) Explain why the pressure in the flask increased during the first 60. seconds.
- (ii) Explain, in terms of processes occurring at the molecular level, why the pressure in the flask remained constant after 60. seconds.

- (iii) What is the value of the partial pressure of ethyl methanoate vapor in the container at 60. seconds?
- (iv) After 80. seconds, additional liquid ethyl methanoate is added to the container at 20°C. Does the partial pressure of the ethyl methanoate vapor in the container increase, decrease, or stay the same? Explain. (Assume that the volume of the additional liquid ethyl methanoate in the container is negligible compared to the total volume of the container.)

No calculators: 2008 part B, form A, question #5

Using principles of atomic and molecular structure and the information in the table below, answer the following questions about atomic fluorine, oxygen, and xenon, as well as some of their compounds.

Atom	First Ionization Energy (kJ mol^{-1})
F	1,681.0
O	1,313.9
Xe	?

- (a) Write the equation for the ionization of atomic fluorine that requires $1,681.0 \text{ kJ mol}^{-1}$.
- (b) Account for the fact that the first ionization energy of atomic fluorine is greater than that of atomic oxygen. (You must discuss both atoms in your response.)
- (c) Predict whether the first ionization energy of atomic xenon is greater than, less than, or equal to the first ionization energy of atomic fluorine. Justify your prediction.
- (d) Xenon can react with oxygen and fluorine to form compounds such as XeO_3 and XeF_4 . ~~In the boxes provided,~~ draw the complete Lewis electron-dot diagram for each of the molecules represented below.
- (e) On the basis of the Lewis electron-dot diagrams you drew for part (d), predict the following:
- The geometric shape of the XeO_3 molecule
 - The hybridization of the valence orbitals of xenon in XeF_4
- (f) Predict whether the XeO_3 molecule is polar or nonpolar. Justify your prediction.

D. Reaction Prediction (2007A)

For each of the following three reactions, in part (i) write a balanced equation for the reaction and in part (ii) answer the question about the reaction. In part (i), coefficients should be in terms of lowest whole numbers. Assume that solutions are aqueous unless otherwise indicated. Represent substances in solutions as ions if the substances are extensively ionized. Omit formulas for any ions or molecules that are unchanged by the reaction. You may use the empty space at the bottom of the next page for scratch work, but only equations that are written in the answer boxes provided will be graded.

(a) A solution of sodium hydroxide is added to a solution of lead(II) nitrate.

(i) Balanced equation:

(ii) If 1.0 L volumes of 1.0 *M* solutions of sodium hydroxide and lead(II) nitrate are mixed together, how many moles of product(s) will be produced? Assume the reaction goes to completion.

(b) Excess nitric acid is added to solid calcium carbonate.

(i) Balanced equation:

(ii) Briefly explain why statues made of marble (calcium carbonate) displayed outdoors in urban areas are deteriorating.

(c) A solution containing silver(I) ion (an oxidizing agent) is mixed with a solution containing iron(II) ion (a reducing agent).

(i) Balanced equation:

(ii) If the contents of the reaction mixture described above are filtered, what substance(s), if any, would remain on the filter paper?