Sample Exam Questions

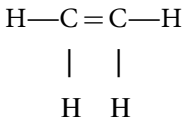
The sample exam questions that follow illustrate the relationship between the course framework and AP Chemistry Exam and serve as examples of the types of questions that appear on the exam. After the sample questions is a table that shows which skill, learning objective(s), and unit each question relates to. The table also provides the answers to the multiple-choice questions.

Section I: Multiple-Choice

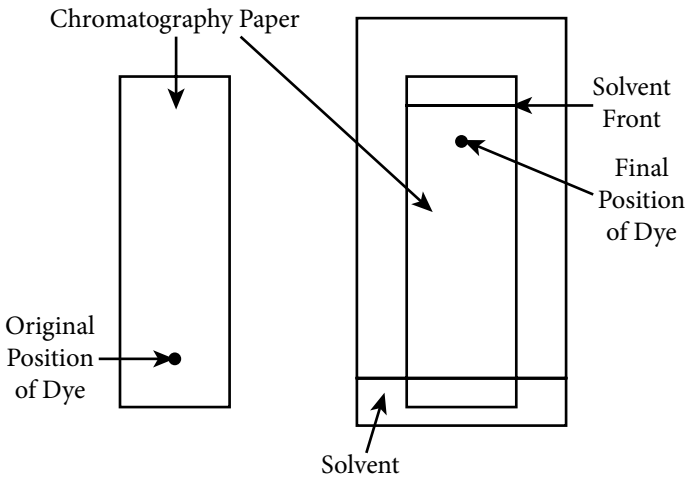
The following are examples of the kinds of multiple-choice questions found on the exam.

$$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$$

1. Which of the following species has the electron configuration shown above?
   (A) O
   (B) Ne
   (C) K^+
   (D) $C1^+$



2. A Lewis diagram for the molecule C_2H_4 is shown above. In the actual C_2H_4 molecule, the H-C-H bond angles are closest to
   (A) 90°
   (B) 109.5°
   (C) 120°
   (D) 180°



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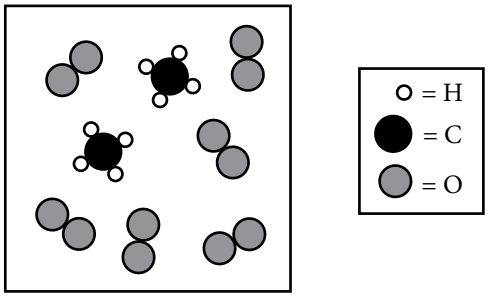
3. Based on the results of the paper chromatography experiment shown above, which of the following can be concluded about the dye?

   (A) It has a small molar mass.

   (B) It has weak intermolecular forces.

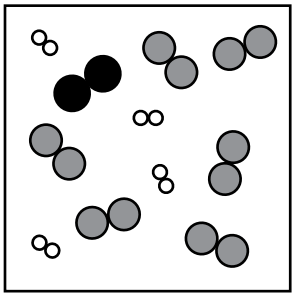
   (C) It has a weaker attraction for the stationary phase than it has for the mobile phase.

   (D) It has a stronger attraction for the stationary phase than it has for the mobile phase.

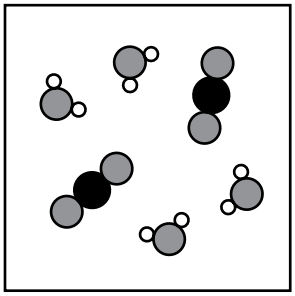


4. The reactants represented above are placed in a vessel and a reaction occurs. Which of the following best represents the contents of the vessel after the reaction has proceeded as completely as possible?

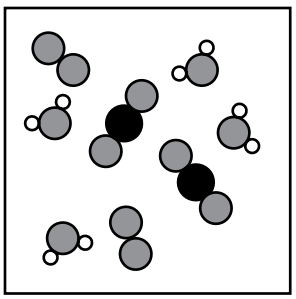
(A)



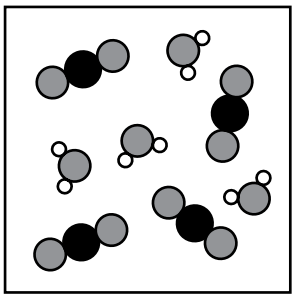
(B)



(C)



(D)



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Initial buret reading	2.17 mL
Final buret reading	22.17 mL

5. An antacid tablet containing $Mg(OH)_2(s)$ (molar mass 58.3 g/mol) is titrated with a 0.100 *M* solution of $HNO_3(aq)$. The end point is determined by using an indicator. Based on the data in the table above, what was the mass of the $Mg(OH)_2(s)$ in the antacid tablet?

   (A) 0.0583 g

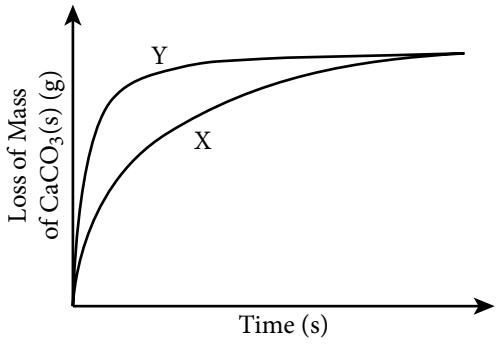
   (B) 0.583 g

   (C) 5.83 g

   (D) 58.3 g

$$HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

The reaction between $HCl(aq)$ and $CaCO_3(s)$ is represented by the equation above. Two separate trials were carried out using $CaCO_3(s)$ samples of the same mass, but one sample was a single piece of $CaCO_3(s)$, and one sample was composed of small pieces of $CaCO_3(s)$. The loss of mass of $CaCO_3(s)$ as a function of time for both trials is shown in the graph below.



6. Which of the curves, X or Y, represents the reaction with small pieces of $CaCO_3(s)$, and why?

   (A) Curve X, because it shows that the reaction proceeded at a uniform rate.

   (B) Curve X, because it takes a shorter time for the reaction to go to completion due to the larger surface area of $CaCO_3(s)$.

   (C) Curve Y, because it shows that the reaction proceeded at a nonuniform rate.

   (D) Curve Y, because it takes a shorter time for the reaction to go to completion due to the larger surface area of $CaCO_3(s)$.

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Cup	Material of Spoon	Initial Temperature of Spoon (°C)	Mass of Spoon (g)	Specific Heat Capacity (J/g °C)
A	Aluminum	20	10.0	0.90
B	Ceramic	20	10.0	0.80
C	Steel	20	20.0	0.45
D	Silver	20	40.0	0.23

7. Four identical 50 mL cups of coffee, originally at 95°C, were stirred with four different spoons, as listed in the table above. In which cup will the temperature of the coffee be highest at thermal equilibrium? (Assume that the heat lost to the surroundings is negligible.)

   (A) Cup A

   (B) Cup B

   (C) Cup C

   (D) Cup D

$$Ag^{+} + (aq) + 2\ NH_3(aq) \rightleftarrows [Ag\ (NH_3)_2]^{+}\ (aq)\ K = 1 \quad 10^7$$

8. Equal volumes of 0.1 *M* $AgNO_3(aq)$ and 0.4 *M* $NH_3(aq)$ are mixed and allowed to reach the equilibrium represented above. Which of the following correctly lists the equilibrium concentrations of the $Ag^{+}(aq)$, $NH_3(aq)$, and $[Ag(NH_3)_2]^{+}(aq)$ in order from least to greatest?

   (A) $[Ag^{+}]_{eq} < [NH_3]_{eq} < [[Ag(NH_3)_2]^{+}]_{eq}$

   (B) $[NH_3]_{eq} < [Ag^{+}]_{eq} < [[Ag(NH_3)_2]^{+}]_{eq}$

   (C) $[Ag(NH_3)_2]^{+}]_{eq} < [Ag^{+}]_{eq} < [NH_3]_{eq}$

   (D) $[Ag^{+}]_{eq} < [[Ag(NH_3)_2]^{+}]_{eq} < [NH_3]_{eq}$

$$N_2(g) + 3\ H_2(g) \rightleftarrows 2\ NH_3(g)$$

A 2.0 L reaction vessel contains an equilibrium mixture of the system represented above. The partial pressures of the components of the mixture at equilibrium are listed in the table below.

P_{N_2}	P_{H_2}	P_{NH_3}
0.30 atm	0.50 atm	0.20 atm

9. Which of the following is the best estimate of the total pressure of the system when the volume of the container is reduced to 1.0 L at a constant temperature?

   (A) $P_{total} = 1.00$ atm

   (B) $1.00\ atm < P_{total} < 2.00\ atm$

   (C) $P_{total} = 2.00$ atm

   (D) $P_{total} > 2.00$ atm

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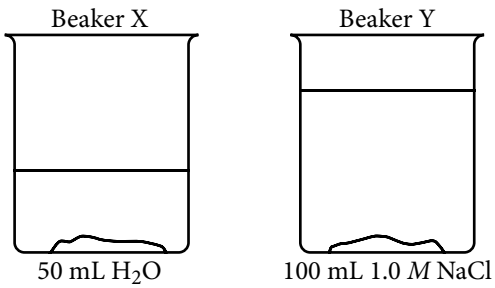

10. Beaker X contains 50 mL of distilled water and beaker Y contains 100 mL of 1.0 *M* NaCl. Solid AgCl is added to each of the beakers. After thoroughly stirring the contents of the beakers, some solid AgCl remains at the bottom of each beaker, as shown above. Which of the following is true?

    (A) $[Ag^+]$ is zero in both beakers.

    (B) $[Ag^+]$ is the same, but not zero, in both beakers.

    (C) $[Ag^+]$ is greater in beaker X.

    (D) $[Ag^+]$ is greater in beaker Y.

11. The value of K_w for water at 0°C is 1 10^{-15}. What is the pOH of water at 0°C?

    (A) 6.5

    (B) 7.0

    (C) 7.5

    (D) 8.0

Half-Reaction	$E°$(V)
$Ag^+(aq) + e^- \rightarrow Ag(s)$	0.80
$Cr^{3+}(aq) + 3\ e^- \rightarrow Cr(s)$	−0.41

12. Based on the standard reduction potentials in the table above, what is the value of $E°$ for a standard galvanic cell made with Ag/Ag^+ and Cr/Cr^{3+} half-cells?

    (A) 0.39 V

    (B) 1.21 V

    (C) 1.99 V

    (D) 2.81 V

Questions 13–15 refer to the information below.

A 0.50 g sample of Mg(*s*) was placed in a solution of HCl(*aq*), where it reacted completely.

13. Which of the following equations best represents the reacting species in the reaction described above?

    (A) $Mg(s) + 2\ H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$

    (B) $Mg(s) + HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

    (C) $Mg(s) + 2\ HCl(aq) \rightarrow MgCl_2(s) + 2\ H^+(aq)$

    (D) $Mg(s) + 2\ HCl(aq) \rightarrow Mg^{2+}(aq) + Cl_2(g) + H_2(g)$

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14. In another experiment, a small piece of Mg(*s*) is weighed, then placed in a flask containing excess 1 *M* HCl(*aq*). The student wants to determine number of moles of gas produced. Which of the following is the best way to conduct the experiment for accurate data collection?

    (A) Conducting the experiment at different temperatures to see which generates the most gas

    (B) Completing the entire reaction in a large Erlenmeyer flask of known volume to measure the volume of the gas collected

    (C) Collecting the gas in a eudiometer tube and measuring the volume of the gas collected

    (D) Conducting the reaction in a graduated cylinder and measuring the volume of the gas collected

15. In a third experiment, 0.10 g samples of Mg(*s*) are placed in excess HCl(*aq*) of various concentrations: 0.050 *M*, 0.10 *M*, 0.25 *M*, and 0.50 *M*. The reactions are run in successive order from 0.050 *M* to 0.50 *M*, and the time required for each reaction to go to completion is recorded. As the concentration of HCl(*aq*) increases from 0.050 *M* to 0.50 *M*, which of the following is the expected result?

    (A) The reaction time increases, and the rate of the reaction decreases.

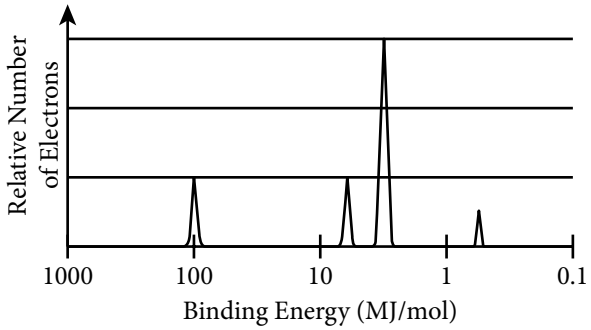
    (B) The reaction time decreases, and the rate of the reaction increases.

    (C) Both the reaction time and the rate of the reaction increase.

    (D) Both the reaction time and the rate of the reaction decrease.

Section II: Free-Response

The following are examples of the kinds of free-response questions found on the exam. Note that on the actual AP Exam, there will be three long free-response questions and four short free-response questions.



1. The complete photoelectron spectrum of an unknown element is given above.

    (a) Draw an X above the peak that corresponds to the orbital with electrons that are, on average, closest to the nucleus. Justify your answer in terms of Coulomb's law.

    (b) Based on the spectrum, write the complete electron configuration of the element.

    (c) On the graph, draw the peak(s) corresponding to the valence electrons of the element that has one more proton in its nucleus than the unknown element has.

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