AP Chemistry – Sample Problems

1. The composition of succinic acid is 40.68% C, 5.12% H, and 54.20% O. What is the empirical formula of the compound?

(A) CHO

(B) C_2H_2O

(C) $C_3H_2O_2$

(D) C_2H_3O

(E) $C_2H_3O_2$

2. A student burns a sample of magnesium metal over a Bunsen burner. The metal reacts with the oxygen in the air according to the following equation:

$$2\,Mg(s) + O_2(g) \rightarrow 2\,MgO(s)$$

Suppose the student is asked to prove that the reaction obeyed the law of conservation of mass. Which of the following should the student use when providing an explanation?

(A) The mass of the reactants and the mass of the product.

(B) The mass of the magnesium metal and the mass of the magnesium oxide.

(C) The standard pressure and temperature of oxygen in the atmosphere.

(D) The rate of disappearance of the magnesium metal and the rate of appearance of the magnesium oxide.

3. Consider the reaction below.

$$Cu^{2+}(aq) + 4NH_3(aq) \leftrightharpoons Cu(NH_3)_4{}^{2+}(aq)$$

Given that the ΔG° for this reaction at 25°C is 2.1×10^{13} kJ, what is the value K (recall $R = 8.314$ J/K mol)?

(A) −76.0

(B) −43.5

(C) −12.6

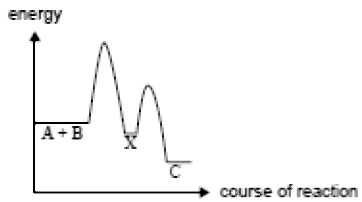
(D) −10.9

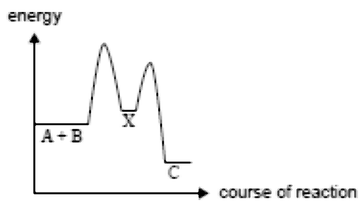
(E) −6.8

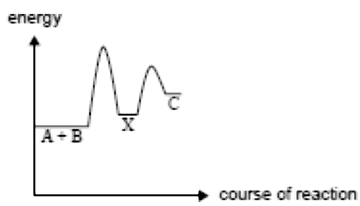
4.

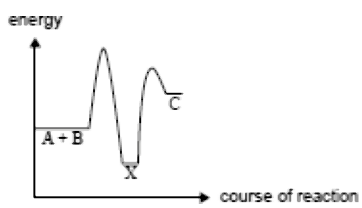
Overall reaction	$A + B \rightarrow C$	ΔH negative
Step 1	$A + B \rightarrow X$	ΔH positive
Step 2	$X \rightarrow C$	ΔH negative

Which diagram *best* illustrates the energy changes over the course of the reaction given the mechanism above?

(A) 

(B) 

(C) 

(D) 

5. Which of the following best exlains why chlorine is a gas at room temperature while bromine is a liquid at the same temperature?

(A) Bromine has stronger induced dipole-induced dipole attractions due to wider distribution of electrons.

(B) Chlorine has stronger induced dipole-induced dipole attractions due to the presence of more atms.

(C) Bromine has stronger induced dipole-induced dipole attractions due to the presence of more atoms.

(D) Chlorine is lighter than bromine and is more likely to behave as a gas.

6. What combination of protons, neutrons, and electrons does the ion $^{55}Mn^{2+}$ possess?

	Protons	Neutrons	Electrons
A	25	30	23
B	25	55	23
C	27	30	25
D	30	25	28

(A) A

(B) B

(C) C

(D) D

7. How do principles of ionic bonding account for the hardness of ionic solids?

(A) Ionic bonding causes molecules to lose all polarity, removing any repulsion between molecules.

(B) Ionic bonding increases the electrostatic force in between cations and anions, making it difficult to break the bonds.

(C) Ionic bonding inovlves the complete transfer of valence lectrons between atoms, which results the absence of free electrons.

(D) Ionic bonding occurs mainly between substances with high melting points, making them stronger and harder to separate.

8. Shown below is a first-order rate law for a unimolecular reaction.

$$\boxed{\frac{d[A]}{dt} = -k_r[A]}$$

Which of the following equations corresponds to the given rate law?

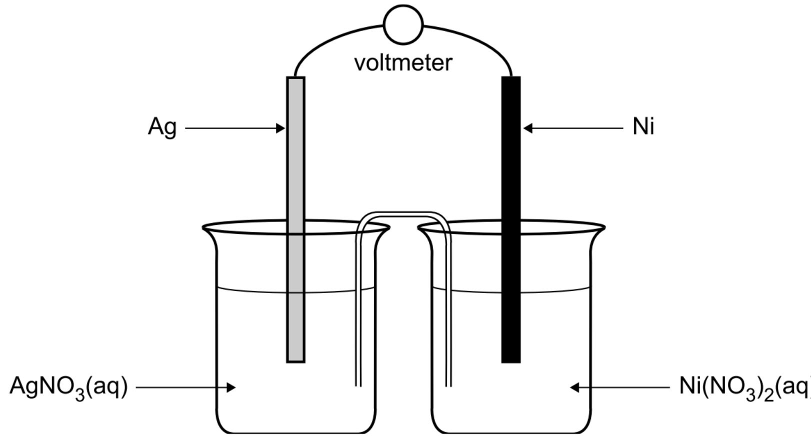
(A) $A \rightarrow C$

(B) $A + B \rightarrow C$

(C) $C \rightarrow A$

(D) $A \rightarrow B + C$

9.



The diagram above displays a cell that contains a silver rod placed inside a solution of 1.0 M $AgNO_3$ and a nickel rod placed inside a solution of 1.0 M $Ni(NO_3)_2$. The two solutions are connected with a salt bridge consisting of an inverted U-tube containing aqueous ammonium nitrate.

Which of the following correctly describe the anode of the cell?

	Anode Polarity	**Reaction at Anode**
A	negative	$Ag^+(aq) + e^- \rightarrow Ag(s)$
B	negative	$Ni^+(s) \rightarrow Ni^{2+}(aq) + 2\,e^-$
C	positive	$Ag^+(aq) + e^- \rightarrow Ag(s)$
D	positive	$Ni^+(s) \rightarrow Ni^{2+}(aq) + 2\,e^-$

(A) A

(B) B

(C) C

(D) D

10. Refer to the reaction below when answering the following questions.

$$2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g) \qquad \Delta H^\circ = -198\ \text{kJ/mol}$$

$$K_c \text{ at } 830^\circ C = 0.25\ \text{atm}^{-1}$$

Suppose the temperature is increased. What effect will this have on the amount of SO_3 produced?

(A) The amount of SO_3 will increase.

(B) The amount of SO_3 will decrease.

(C) The temperature will have no effect on the amount of SO_3 produced.

(D) Answer cannot be determined from information given.

11. $$2\,ZnS(s) + 3\,O_2(g) \rightleftharpoons 2\,ZnO(s) + 2\,SO_2(g)$$

What is the equilibrium expression for the above reaction?

(A) $K = \dfrac{2[SO_2]}{3[O_2]}$

(B) $K = \dfrac{[SO_2]^2}{[O_2]^3}$

(C) $K = \dfrac{2[ZnO][SO_2]}{3[ZnS][O_2]}$

(D) $K = \dfrac{[ZnO]^2[SO_2]^2}{[ZnS]^2[O_2]^3}$

12. Consider the reactions between the two unknown diatomic molecules (X_2 and Y_2).

Rxn Number	Reaction	K (equilibrium)	Temp
I	$2XY(g) \leftrightharpoons X_2(g) + 2Y_2(g)$	377	300 K
		32	500 K
		5	1000 K
II	$X_2(g) \leftrightharpoons 2X(g)$	1.0×10^{-5}	1000 K
		1.7×10^{-3}	1200 K
III	$Y_2(g) \leftrightharpoons 2Y(g)$	3.4×10^{-5}	1000 K

For reaction II, what is true of the change in enthalpy?

(A) It is less than 0.

(B) It is equal to 0.

(C) It is greater than 0.

(D) None of the above

13. Which compound has an ionic bond?

(A) CsCl

(B) C_2H_4

(C) ICl_3

(D) BH_3

(E) H_2S

14. Which of the following describes the proper procedure for preparing 100 mL of a 1.0 M H_2SO_4 solution from a 10 M H_2SO_4 solution?

(A) 90 mL of H_20 should be added to 10 mL of 10 M H_2SO_4.

(B) 10 mL of 10 M H_2SO_4 should be added to 90 mL of H_2O.

(C) 10 mL of 10 M H_2SO_4 should be added to 80 mL of H_2O, and the resulting solution should be stirred and diluted to 100 mL after it has cooled.

(D) 80 mL of H_2O should be added to 10 mL of 10 M H_2SO_4, and the resulting solution should be stirred and diluted after it has cooled.

15. Four sets of chromium-containing compounds are listed below.

Set 1:	Cr_2O_3	$K_2Cr_2O_7$	Na_2CrO_4
Set 2:	$CrCl_2$	Cr_2O_3	$K_2Cr_2O_7$
Set 3:	Cr_2O_3	$CrCl_3$	$Cr(NO_3)_3$
Set 4:	Na_2CrO_4	Cr_2O_37	$Cr(NO_3)_3$

In which set do the Cr atoms all have the same oxidation number?

(A) Set 1

(B) Set 2

(C) Set 3

(D) Set 4

16.

$$2NO_2(g) \leftrightharpoons N_2O_4(g)$$

The preceeding mixture is initially at equilibrium when the volume is suddenly doubled. If the temperature remains unchanged, what is true regarding the system after it regains equilibrium?

(A) The total pressure will be higher.

(B) The equilibrium constant will be lower.

(C) The equilibrium constant will be higher.

(D) The mole fraction of $NO_2(g)$ will be higher.

(E) The partial pressure of $N_2O_4(g)$ will be higher.

17. Hydrogen and oxygen can react in a favorable exothermic reaction. However, the reaction is not spontaneous. Which of the following explains this?

(A) Heat is required to meet the E_a.

(B) A catalyst is required for the reaction to occur.

(C) There is not enough pressure to activate the reaction.

(D) The reaction needs to be coupled with another reaction.

(E) None of the above

18. Consider the gas phase reaction at 800 K:

$$N_2 + 3H_2 \leftrightharpoons 2NH_3 \qquad K = 0.278$$

Formula	ΔS_f°
H_2	130.6 kJ/mol
N_2	191.5 kJ/mol
NH_3	192.3 kJ/mol

The partial pressures of the reaction are as follows:

P_{H_2}	0.524 atm
P_{N_2}	0.417 atm
P_{NH_3}	0.122 atm

What is the standard entropy change for this reaction?

(A) −198.7 J/mol

(B) 132.5 J/mol

(C) −78.4 J/mol

(D) 132.5 J/mol

(E) 198.2 J/mol

19.

formic acid (HCOOH)	$pK_a = 3.75$
acetic acid (CH_3COOH)	$pK_a = 4.75$
hydrochloric acid (HCl)	

Choose the arrangement that orders the acids from weakest to strongest.

(A) acetic < formic < hydrochloric

(B) acetic < hydrochloric < formic

(C) formic < acetic < hydrochloric

(D) hydrochloric < acetic < formic

(E) hydrochloric < formic < acetic

20. The following data was recorded at 25° C and 47 atm. Suppose it refers to a certain substance Z.

Vapor pressure = 106.7 mm Hg
Critical point = 289° C
Molar mass = 78 g/mol
Nonconductor of electricity
Normal boiling point = 5° C
$\Delta H_{vap} = 30.8$ kJ/mol
Insoluable in water

What type of solid is Z?

(A) Ionic solid

(B) Molecular solid

(C) Metallic solid

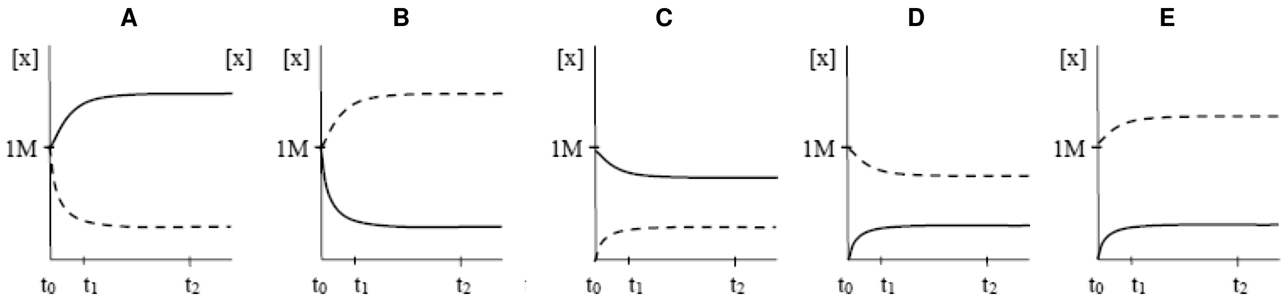
(D) Network covalent solid

(E) cannot be determined

21.

$$Ag^{+}(aq) + e^{-} \rightarrow Ag(s) \qquad \Delta E^{\circ} = 0.80\ V$$
$$Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s) \qquad \Delta E^{\circ} = 0.34\ V$$

Examine the following concentration vs. time plots for the preceeding equations from the inital condition of 298 K.



Key	
$[Ag^{+}]$	– – – – –
$[Cu^{2+}]$	———

In plot A at t_2, what is true?

(A) Q is less than K.

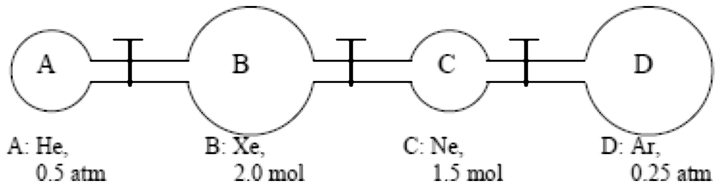
(B) Q is equal to K.

(C) Q is greater than K.

(D) Q is equal to 0.

(E) None of the above

22. The system below is held at 273 K. The smaller flasks hold 11 L and the larger flasks hold 22 L (the volume of the tubes between the flasks is negligible).



At the beginning, the gases held in A, B, C, and D are seperated by the valves.

Of the following gas molecules, which have the highest rms velocity?

(A) Ar

(B) He

(C) Ne

(D) Xe

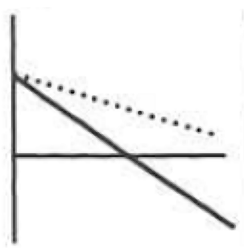
(E) All have the same speed

23. Consider the reactions between the two unknown diatomic molecules (X_2 and Y_2).

Rxn Number	Reaction	K (equilibrium)	Temp
I	$2XY(g) \leftrightharpoons X_2(g) + 2Y_2(g)$	377	300 K
		32	500 K
		5	1000 K
II	$X_2(g) \leftrightharpoons 2X(g)$	1.0×10^{-5}	1000 K
		1.7×10^{-3}	1200 K
III	$Y_2(g) \leftrightharpoons 2Y(g)$	3.4×10^{-5}	1000 K

For the reactions II and III, which of the following correctly graphs $\Delta G°$ vs. T?

Key	
Reaction II	
Reaction III	

(A)


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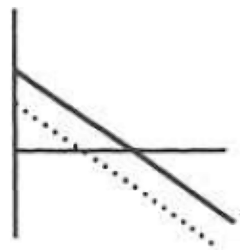

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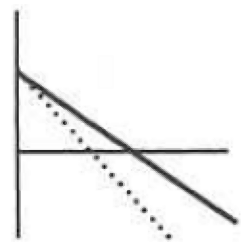

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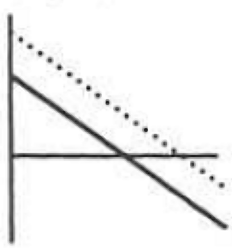
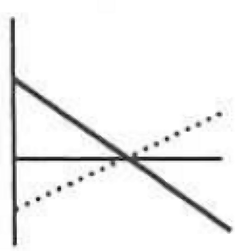


(D)


24. $$CH_3COOH(aq) + NaHCO_3(s) \rightarrow CH_3COO^-Na^+(aq) + CO_2(g) + H_2O(\ell)$$

What is the limiting reactant if 53 g of $CH_3COOH(aq)$ is mixed with $NaHCO_3(s)$ to produce 7.2 g of water?

(A) CO_2

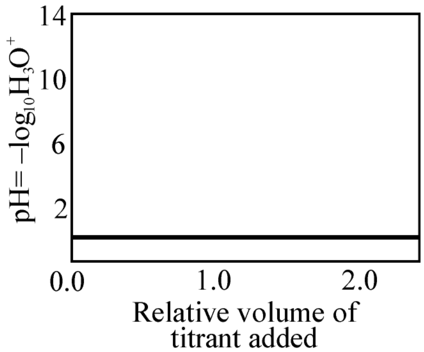
(B) H_2O

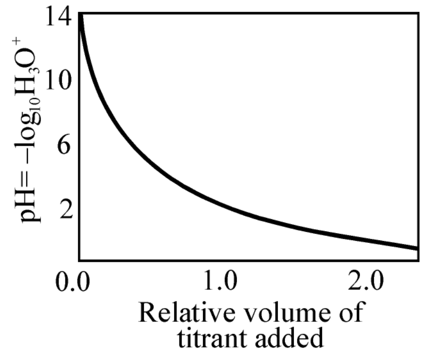
(C) $NaHCO_3$

(D) CH_3COOH

(E) $CH_3COO^-Na^+$

25. A titration curve can be plotted when a strong acid, 1 M HNO_3, is titrated with a strong base, 1 M NaOH. Which of the following could be the resulting plot of that titration?

(A)


(D)


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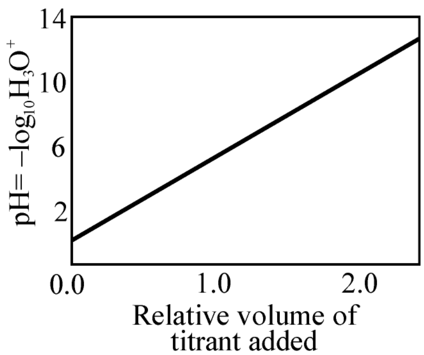
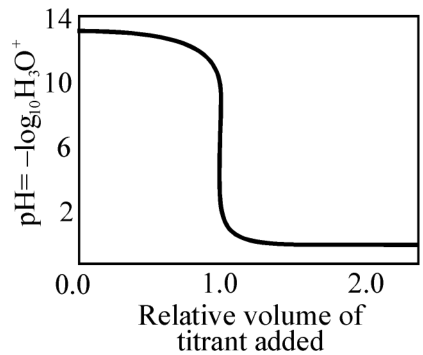


(E)


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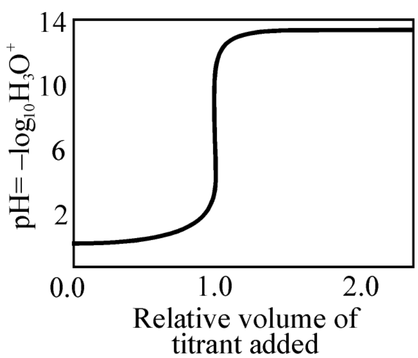


26. An average hot spring has about 650 L of water in it. Given that the heat capacity of water is 4.18 J/g $\cdot$ °C and the density of water is 1.0 g/mL at all temperatures, how much energy is required to raise the temperature of the hot spring from 20°C to 100°C?

(A) 100 J

(B) 200 kJ

(C) 240 kJ

(D) 2.2×10^5 kJ

(E) 2.4×10^7 kJ

27. Why is the bond enthalpy of the carbon-oxygen bond in CO_2 is 743 kJ/mol, when the bond enthalpy of each carbon-oxygen bond in CO is 1074 kJ/mol?

(A) There are two oxygen atoms in CO_2.

(B) Carbon dioxide has no dipole moment.

(C) Random differences between the molecules.

(D) Carbon monoxide has a higher bond order.

(E) Carbon dioxide is bigger so the bonds are weaker.

28. $H_2O_2 + 2H^+ + 2I^- \rightarrow I - 2 + 2H_2O$ rate $= k[H_2O_2][I^-]$

$H_2O_2 + I^- \rightarrow HOI + OH^-$	*slow*
$OH^- + H^+ \rightarrow H_2O$	*fast*
$HOI + H^+ + I^- \rightarrow I_2 + H_2O$	*fast*

Given the reaction and proposed mechanism, what are the intermediates?

(A) H^+ only

(B) H^+ and I^-

(C) H^+ and HOI

(D) HOI and OH^-

(E) H_2O and OH^-

29. Explain how the following reactions involve chemical and physical changes simultaneously.

a) Burning a candle

b) Steaming raw vegetables

c) Dissolving table salt in water

30. The element X forms the fluorides XF_3 and XF_5 and reacts with sodium to form Na_3X.

a) Which element behaves in this way?

b) Consider the flourides formed by X.

i. Construct Lewis structures for the flourides.

ii. Describe the electron pair and molecular geometries.

iii. Determine the hybridization of the X atom.

c) Identify the longer bonds in XF_5 and explain the deviation in bond lenth.

d) The element Y exists in the same family as X and forms YF_3 molecules, but not YF_5 molecules. What is the identity of Y, and why is it unable to form YF_5?

31. $H_2(g) + X_2(g) \rightarrow 2HX(g)$

a) Assume that X represents Cl or F in the given reaction.What is the enthalpy of formation for HCl and HF?

b) Explain using your answer from the previous part whether H-Cl or H-F is more polar?

32. A 0.060 M solution of aluminium nitrate and a 0.080 M solution of potassium phosphate are prepared by dissolving $Al(NO_3)_3$ and K_3PO_4 in water. Aluminium phosphate precipitates when the solutions are combined.

a) i. What is the ionic equation for the dissolution of aluminum nitrate?

ii. What is the ionic equation for the dissolution of potassium phosphate?

b) What is the ionic equation for the precipitation reaction?

c) How many moles of aluminium phosphate precipitates when 100.0 mL of the aluminium nitrate solution is added to 50.0 mL of the potassium phosphate solution?

d) After the precipitation, calculate the final concentration of aluminium ions remaining in solution.

33.

I. A catalyst increases the rate of a reaction.

II. All catalysts are solids.

III. The mass of a catalyst is the same before and after a reaction.

IV. A catalyst lowers the enthalpy change of a reaction and thus allows more particles to have sufficient energy for a successful reaciton.

V. A catalyst increases the value of the equilibrium constant to favor the extent of the forward reaction, which results in a greater product yield.

VI. All catalysts align the reactant particles in a favorable orientation.

VII. Enzymes are biological catalysts that catalyze a specific biochemical reaction once.

The list given above concerns catalysts, and contains both true and false statements.

a) Identify two correct statements.

b) Identify three incorrect statements and explain why each statement is incorrect.

34. Sucrose is dissolved in water according to the following equation:

$$C_6H_{12}O_6(s) \rightarrow C_6H_{12}O_6(aq)$$

At 25° C, 34.2 g of $C_6H_{12}O_6(s)$ is added to 1.00 L of water (heat capacity = 4.184 J/gK) inside a calorimeter. After the $C_6H_{12}O_6(s)$ has dissolved, the temperature is 24.5° C.

a) What is the $\Delta H°$ for the process?

b) To lower the temperature of water in a calorimeter from 25° C to 23.5° C how many grams of sucrose would have to be dissolved in 1.00 L of water?

c) Explain whether the equilibrium constant for the dissolution of $C_6H_{12}O_6(s)$ in 25° C water is smaller than, equal to, or larger than the equilibrium constant for the dissolution of $C_6H_{12}O_6(s)$ in 50° C water.

35. The following questions concern the quantum mechanical model of the atom.

a) State the quantum number (n, l, m_l, m_s) that determines the value of each of the following:

i. The enregy level of an orbital in a hydrogen atom

ii. The shape of an orbital

iii. The size of an orbital

iv. The spatial orientation of an orbital

b) Name the element represented by the following electron configuration:

$$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$$

c) Determine whether each of the following sets of quantum numbers are allowed to specify an electron. Justify your answer.

i. $n = 1,\ l = 1,\ m_s = -\frac{1}{2}$

ii. $n = 4,\ l = 3,\ m_l = -2,\ m_s = +\frac{1}{2}$

36. Examine the following standard electrode potentials.

Equation	E°
$2S + 6OH^- \leftrightharpoons S_2O_3^{2-} + 3H_2O + 4e^-$	+0.74 V
$S_2O_3^{2-} + 6OH^- \leftrightharpoons 2SO_3^{2-} + 3H_2O + 4e^-$	+0.58 V
$S_2O_3^{2-} + H_2O \leftrightharpoons 2SO_2 + 2H^+ + 4e^-$	-0.40 V
$2S + 3H_2O \leftrightharpoons S_2O_3^{2-} + 6H^+ + 4e^-$	-0.50 V

a) Explain why solutions of thiosulfate for analysis are not acidic.

b) What is the balanced equation that would account for your answer to part (a)?

37. Consider the chemical preparation of iodine, given in the equation below:

$$2\,NaI(s) + 2\,H_2SO_4(aq) + MnO_2(s) \rightarrow Na_2SO_4(aq) + MnSO_4(aq) + I_2(g) + 2\,H_2O(\ell)$$

a) Give the following oxidation numbers:

i. I in NaI

ii. Mn in MnO_2

iii. Mn in $MnSO_4$

b) Determine the oxidizing agent and reducing agent in the reaction.

c) If 20.0 g of NaI is mixed with 10.0 g of MnO_2, what is the maximum quantity of iodine that can be prepared?

38. For the reaction

$$IO_3^-(aq) + 5\,I^-(aq) + 6\,H^+(aq) \rightarrow 3\,I_2(aq) + 3\,H_2O(\ell)$$

The following data were collected at 25° C.

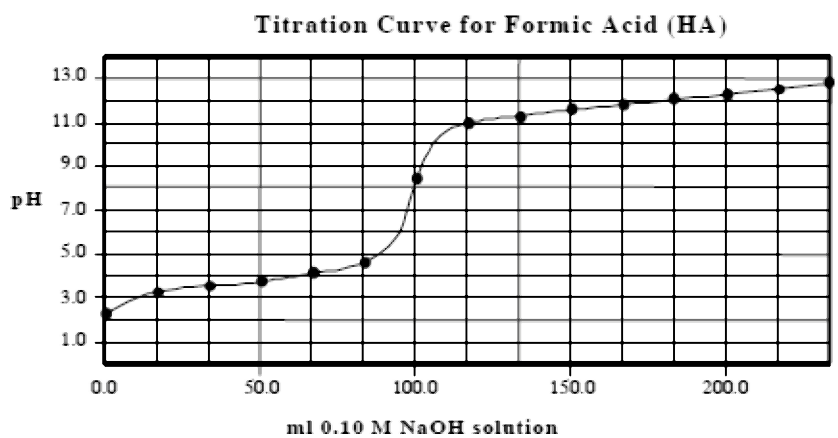
$[I^-]$, M	$[IO_3^-]$, M	$[H^+]$, M	Reaction Rate, mol/L · s
0.0010	0.10	0.010	0.60
0.0040	0.10	0.010	2.40
0.0010	0.30	0.010	5.40
0.0010	0.10	0.020	2.40

a) Determine the order of the reaction with respect to the species I^-, IO_3^-, and H^+.

b) Determine the rate constant for the reaction and provide its units.

c) Predict the possibility of this reaction occuring in a single step. Explain your reasoning.

39. At 25° C, the weak acid formic acid, HA, is titrated with a strong base.



a) What is the pH of a 100 mL solution of 0.100 M formic acid (pK_a = 3.75)?

b) What is the resulting pH of solution when 20 mL of NaOH are added to a 100 mL solution of 0.100 M HA?

40. Using the concept of periodic trends, answer the following questions about the recently isolated elements 114, 116, and 118.

a) Give the names and symbols of the elements in the row above the recently isolated elements.

b) Predict the relative ionization energies of the elements. Explain how the ionization energy of one of them compares to the ionization energy of the element directly above it on the periodic table. Outline your reasoning.

c) Predict the oxidation states expected for element 114, and describe the oxidation state that is expected to be the most stable.

d) Why might elements 114, 116, and 118 have been made while elements 113, 115, and 117 have not?

41. For each of the following reactions, provide a balanced equation.

a) Calcium oxide reacts with pure aluminum to produce pure calcium and aluminum oxide.

b) Copper(II) oxide reacts with sulfuric acid to produce copper(II) sulfate and water.

42. At temperatures below 500 K the reaction between carbon monoxide and nitrogen dioxide is as follows:

$$NO_2(g) + CO(g) \rightarrow CO_2(g) + NO(g)$$
$$\text{Rate} = k\,[NO_2]^2$$

Write a mechanism that agrees with the rate equation. If the mechanism consists of more than a single, elementary step, be sure to label the steps as slow or fast. Identify any intermediates in the reaction.

43. The decomposition of hydrogen peroxide (H_2O_2) is as follows:

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

The decomposition can also be catalyzed with H_3O^+ and Br^- as follows:

1)	$H_3O^+ + H_2O_2 \leftrightharpoons H_3O_2^+ + H_2O$	K_{eq}	(fast)
2)	$H_3O_2^+ + Br^- \rightarrow HOBr + H_2O$	K_2	(slow)
3)	$HOBR^- + H_2O_2 \rightarrow H_2O^+ + O_2 + Br^-$	K_3	(fast)

a) In terms of the production of O_2, $[H_3O^+]$, $[Br^-]$, and $[H_2O_2]$, what is the overall rate law?

b) At 298 K, the catalyst Br^- inreases the reaction rate by 3×10^3. If the uncatalyzed value of the E_a is 76 kJ/mol, by how much does the addition of Br^- lower it?

44. The conversion of CO_2 and H_2O to glucose (formula $C_6H_{12}O_6$) and O_2 is vital to the photosynthesis of green plants.

a) Write a balanced equation for the reaction.

Substance	$\Delta H_f°$, kJ/mol	$S°$, J/mol·K
$CO_2(g)$	−393.5	213.2
$H_2O(\ell)$	−285.8	69.9
$C_6H_{12}O_6$	−1273.3	212.2
$O_2(g)$		205.0

b) Using the information in the table above, calculate the value of

i. $\Delta H°$

ii. $\Delta S°$

iii. $\Delta G°$ at 298 K

c) What is the spontaneity of the reaction at 25° C? At other temperatures?

d) Light with wavelengths of approximately 600 nm are required for this process. Determine the value of each of the following:

i. The energy of a photon with this wavelength.

ii. The $\Delta G°$ for the formation of one molecule of glucose by this reaction.

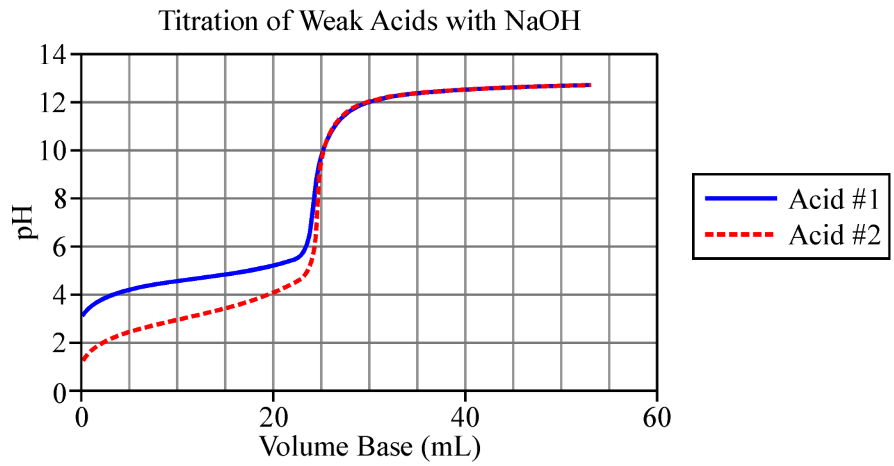
iii. The minimum number of 600 nm photons needed to make one molecule of glucose by this reaction.

e) In one year, all of the photosynthesis on earth stores 3.4×10^{18} kJ of solar energy.

i. Use $\Delta G°$ for the reaction to calculate how much CO_2 (in moles) is removed from the atmosphere every year.

ii. What mass of carbon is fixed annually through this process?

45. Two weak acids of equal concentrations and V_{acid} = 15.00 mL are titrated with the strong base NaOH, M_{NaOH} = 0.150 M.



Based on the titration graph above, which acid is acetic acid and which acid is chloroacetic acid?

46. Three different mechanism for a reaction are listed below.

I. **Step 1** $NO_2 + CO \rightarrow CO_2 + NO$

II. **Step 1** $NO_2 + NO_2 \rightarrow NO + NO_3$ and its reverse (both fast, equilibrium)
Step 2 $NO_3 + CO \rightarrow NO_2 + CO_2$ (slow)

III. **Step 1** $NO - 2 + NO_2 \rightarrow NO + NO_3$ (slow)
Step 2 $NO_3 + CO \rightarrow NO_2 + CO_2$ (fast)

Explain which mechanism could have the rate law of $k[NO_2]^2$.

47. A student wishes to determine the copper(II) concentration in a certain solution. The first step in this process involves the precipitation of CuI through the addition of excess I^-, according to the following unbalanced equation:

$$Cu^{2+}(aq) + I^-(aq) \rightarrow CuI(s) + I_2(aq)$$

The student then titrates the iodine formed from the precipitation with a sodium thiosulfate solution, using a violet starch indicator that turns white when all the I_2 has reacted. The titration proceeds according to the following unbalanced equation:

$$S_2O_3{}^{2-}(aq) + I_2(aq) \rightarrow S_4O_6{}^{2-}(aq) + I^-(aq)$$

During the experiment, the student collected the following data:

Concentration of $Na_2S_2O_3$ soln.:	0.0206 M
Burette reading before titration:	0.17 mL
Burette reading after titration:	9.82 mL

a) Write the overall stoichiometric equation for the experiment.

b) Determine the amount of $Na_2S_2O_3$ (in moles) used in the titration.

c) Calculate the concentration of Cu^{2+} in the original solution.

48. Two vessels, containing S_4 molecules in one and S_8 molecules in the other, hold 6.02×10^{23} atoms each.

a) Explain whether the two containers have an equal number of molecules or not.

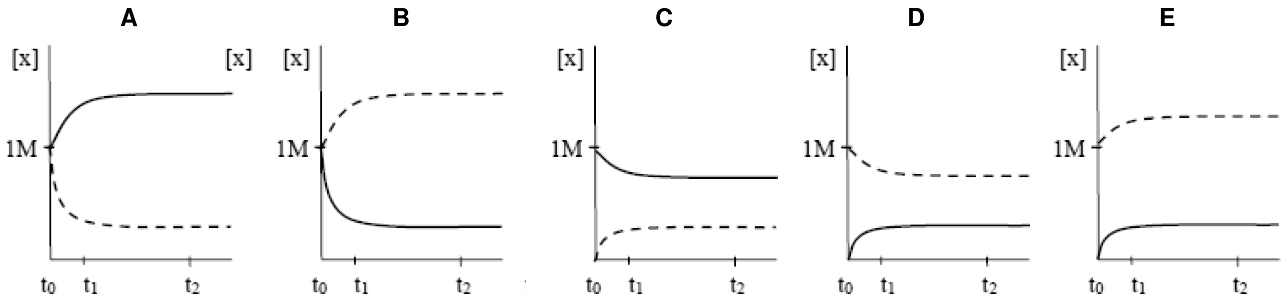
b) How many moles of sulfur molecules are in each sample?

c) Draw a picture which illustrates whether the number of molecules and moles are the same or not.

49.

$$Ag^+(aq) + e^- \rightarrow Ag(s) \qquad \Delta E^\circ = 0.80\,V$$
$$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s) \qquad \Delta E^\circ = 0.34\,V$$

Examine the following concentration vs. time plots for the preceeding equations from the inital condition of 298 K.



Key	
$[Ag^+]$	- - - - -
$[Cu^{2+}]$	———

The initial product and reactant conditions are standard states for which plots?

50. Hydrogen peroxide decomposes according to the following equation:

$$2H_2O_2(aq) \rightarrow 2H_2O(\ell) + O_2(g)$$

At 25° C and 1.0 atm, a 50.00 mL solution of hydrogen peroxide that is 30.0% hydrogen peroxide by mass decomposes to form water and oxygen gas. If the density of hydrogen peroxide in the solution is 1.05 g/mL at 25° C and 1.0 atm, what is the volume of O_2(g) produced?