



# KSO 2018 x DALTON

## Written Exam

### 1hr 30 mins

### Chemistry

#### **INSTRUCTIONS:**

1. Please write your name (name on your name tags), grade, and school on both this exam booklet and the scantron (bubble) sheet provided.
2. NO CALCULATOR is allowed.
3. Fill in the bubble clearly and erase the bubble COMPLETELY if you would like to make a change.
4. If you are using a pen for bubbling, make sure to cross out any answers you don't want to be marked for.
5. Write clearly for FRQ, any handwriting that cannot be deciphered will not be scored.
6. Look at your own paper ONLY.
7. If you complete your exam early, please leave all pieces of paper in a neat pile on your desk and make your way to the new cafe for snacks. (You will not be allowed to leave in the last 10 minutes should you finish early)

NAME:

GRADE:

SCHOOL:

## PERIODIC TABLE OF THE ELEMENTS

1 <b>H</b> 1.008																	2 <b>He</b> 4.00						
3 <b>Li</b> 6.94	4 <b>Be</b> 9.01																	5 <b>B</b> 10.81	6 <b>C</b> 12.01	7 <b>N</b> 14.01	8 <b>O</b> 16.00	9 <b>F</b> 19.00	10 <b>Ne</b> 20.18
11 <b>Na</b> 22.99	12 <b>Mg</b> 24.30																	13 <b>Al</b> 26.98	14 <b>Si</b> 28.09	15 <b>P</b> 30.97	16 <b>S</b> 32.06	17 <b>Cl</b> 35.45	18 <b>Ar</b> 39.95
19 <b>K</b> 39.10	20 <b>Ca</b> 40.08	21 <b>Sc</b> 44.96	22 <b>Ti</b> 47.90	23 <b>V</b> 50.94	24 <b>Cr</b> 52.00	25 <b>Mn</b> 54.94	26 <b>Fe</b> 55.85	27 <b>Co</b> 58.93	28 <b>Ni</b> 58.69	29 <b>Cu</b> 63.55	30 <b>Zn</b> 65.39	31 <b>Ga</b> 69.72	32 <b>Ge</b> 72.59	33 <b>As</b> 74.92	34 <b>Se</b> 78.96	35 <b>Br</b> 79.90	36 <b>Kr</b> 83.80						
37 <b>Rb</b> 85.47	38 <b>Sr</b> 87.62	39 <b>Y</b> 88.91	40 <b>Zr</b> 91.22	41 <b>Nb</b> 92.91	42 <b>Mo</b> 95.94	43 <b>Tc</b> (98)	44 <b>Ru</b> 101.1	45 <b>Rh</b> 102.91	46 <b>Pd</b> 106.42	47 <b>Ag</b> 107.87	48 <b>Cd</b> 112.41	49 <b>In</b> 114.82	50 <b>Sn</b> 118.71	51 <b>Sb</b> 121.75	52 <b>Te</b> 127.60	53 <b>I</b> 126.91	54 <b>Xe</b> 131.29						
55 <b>Cs</b> 132.91	56 <b>Ba</b> 137.33	57 <b>*La</b> 138.91	72 <b>Hf</b> 178.49	73 <b>Ta</b> 180.95	74 <b>W</b> 183.85	75 <b>Re</b> 186.21	76 <b>Os</b> 190.2	77 <b>Ir</b> 192.2	78 <b>Pt</b> 195.08	79 <b>Au</b> 196.97	80 <b>Hg</b> 200.59	81 <b>Tl</b> 204.38	82 <b>Pb</b> 207.2	83 <b>Bi</b> 208.98	84 <b>Po</b> (209)	85 <b>At</b> (210)	86 <b>Rn</b> (222)						
87 <b>Fr</b> (223)	88 <b>Ra</b> 226.02	89 <b>†Ac</b> 227.03	104 <b>Rf</b> (261)	105 <b>Db</b> (262)	106 <b>Sg</b> (266)	107 <b>Bh</b> (264)	108 <b>Hs</b> (277)	109 <b>Mt</b> (268)	110 <b>Ds</b> (271)	111 <b>Rg</b> (272)													

\*Lanthanide Series

58 <b>Ce</b> 140.12	59 <b>Pr</b> 140.91	60 <b>Nd</b> 144.24	61 <b>Pm</b> (145)	62 <b>Sm</b> 150.4	63 <b>Eu</b> 151.97	64 <b>Gd</b> 157.25	65 <b>Tb</b> 158.93	66 <b>Dy</b> 162.50	67 <b>Ho</b> 164.93	68 <b>Er</b> 167.26	69 <b>Tm</b> 168.93	70 <b>Yb</b> 173.04	71 <b>Lu</b> 174.97
90 <b>Th</b> 232.04	91 <b>Pa</b> 231.04	92 <b>U</b> 238.03	93 <b>Np</b> (237)	94 <b>Pu</b> (244)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (252)	100 <b>Fm</b> (257)	101 <b>Md</b> (258)	102 <b>No</b> (259)	103 <b>Lr</b> (262)

†Actinide Series

## Chemistry Equations & Constants

Throughout the test the following symbols have the definitions specified unless otherwise noted.

L, mL = liter(s), milliliter(s)	mm Hg = millimeters of mercury
g = gram(s)	J, kJ = joule(s), kilojoule(s)
nm = nanometer(s)	V = volt(s)
atm = atmosphere(s)	mol = mole(s)

### ATOMIC STRUCTURE

$$E = h\nu$$

$$c = \lambda\nu$$

$E$  = energy

$\nu$  = frequency

$\lambda$  = wavelength

Planck's constant,  $h = 6.626 \times 10^{-34}$  J s

Speed of light,  $c = 2.998 \times 10^8$  m s<sup>-1</sup>

Avogadro's number =  $6.022 \times 10^{23}$  mol<sup>-1</sup>

Electron charge,  $e = -1.602 \times 10^{-19}$  coulomb

### EQUILIBRIUM

$$K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}, \text{ where } a A + b B \rightleftharpoons c C + d D$$

$$K_p = \frac{(P_C)^c (P_D)^d}{(P_A)^a (P_B)^b}$$

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

$$K_b = \frac{[OH^-][HB^+]}{[B]}$$

$$K_w = [H^+][OH^-] = 1.0 \times 10^{-14} \text{ at } 25^\circ\text{C}$$

$$= K_a \times K_b$$

$$\text{pH} = -\log[H^+], \text{ pOH} = -\log[OH^-]$$

$$14 = \text{pH} + \text{pOH}$$

$$\text{pH} = \text{p}K_a + \log \frac{[A^-]}{[HA]}$$

$$\text{p}K_a = -\log K_a, \text{ p}K_b = -\log K_b$$

#### Equilibrium Constants

$K_c$  (molar concentrations)

$K_p$  (gas pressures)

$K_a$  (weak acid)

$K_b$  (weak base)

$K_w$  (water)

### KINETICS

$$\ln[A]_t - \ln[A]_0 = -kt$$

$$\frac{1}{[A]_t} - \frac{1}{[A]_0} = kt$$

$$t_{1/2} = \frac{0.693}{k}$$

$k$  = rate constant

$t$  = time

$t_{1/2}$  = half-life

## GASES, LIQUIDS, AND SOLUTIONS

$$PV = nRT$$

$$P_A = P_{\text{total}} \times X_A, \text{ where } X_A = \frac{\text{moles A}}{\text{total moles}}$$

$$P_{\text{total}} = P_A + P_B + P_C + \dots$$

$$n = \frac{m}{M}$$

$$K = ^\circ\text{C} + 273$$

$$D = \frac{m}{V}$$

$$KE \text{ per molecule} = \frac{1}{2}mv^2$$

Molarity,  $M$  = moles of solute per liter of solution

$$A = abc$$

$P$  – pressure

$V$  = volume

$T$  = temperature

$n$  = number of moles

$m$  = mass

$M$  = molar mass

$D$  = density

$KE$  = kinetic energy

$v$  = velocity

$A$  = absorbance

$a$  = molar absorptivity

$b$  = path length

$c$  = concentration

Gas constant,  $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$

$$= 0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1}$$

$$= 62.36 \text{ L torr mol}^{-1} \text{ K}^{-1}$$

$$1 \text{ atm} = 760 \text{ mm Hg}$$

$$= 760 \text{ torr}$$

STP =  $0.00^\circ\text{C}$  and  $1.000 \text{ atm}$

## THERMOCHEMISTRY/ ELECTROCHEMISTRY

$$q = mc\Delta T$$

$$\Delta S^\circ = \sum S^\circ \text{ products} - \sum S^\circ \text{ reactants}$$

$$\Delta H^\circ = \sum \Delta H_f^\circ \text{ products} - \sum \Delta H_f^\circ \text{ reactants}$$

$$\Delta G^\circ = \sum \Delta G_f^\circ \text{ products} - \sum \Delta G_f^\circ \text{ reactants}$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$= -RT \ln K$$

$$= -nFE^\circ$$

$$I = \frac{q}{t}$$

$q$  = heat

$m$  = mass

$c$  = specific heat capacity

$T$  = temperature

$S^\circ$  = standard entropy

$H^\circ$  = standard enthalpy

$G^\circ$  = standard free energy

$n$  = number of moles

$E^\circ$  = standard reduction potential

$I$  = current (amperes)

$q$  = charge (coulombs)

$t$  = time (seconds)

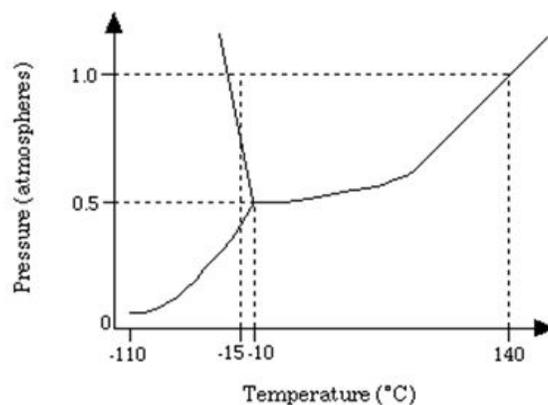
Faraday's constant,  $F = 96,485$  coulombs per mole of electrons

$$1 \text{ volt} = \frac{1 \text{ joule}}{1 \text{ coulomb}}$$

## Multiple Choice Questions

1. Select all of the following that has/have red as its/their flame color.
  - I. Strontium
  - II. Sodium
  - III. Lithium
  - IV. Potassium
  - a. II
  - b. III
  - c. I, IV
  - d. I, III
  - e. III, IV

Refer to the following diagram for questions 2-4.

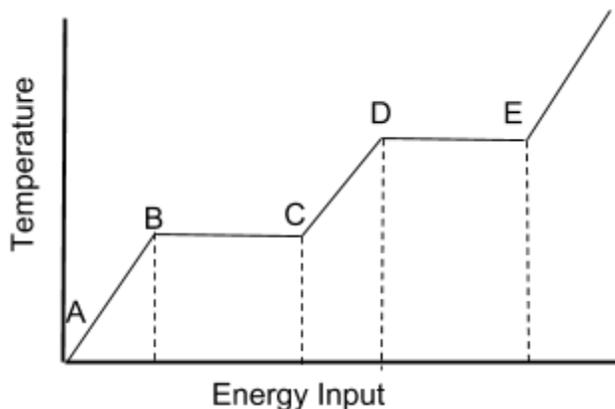


2. The normal boiling point of the substance represented by the phase diagram shown is
  - a.  $-15^{\circ}\text{C}$
  - b.  $-10^{\circ}\text{C}$
  - c.  $140^{\circ}\text{C}$
  - d. More than  $140^{\circ}\text{C}$
  - e. Indeterminate
3. The phase diagram above provides sufficient information for determining the
  - a. entropy change on vaporization
  - b. conditions necessary for sublimation
  - c. deviations from ideal gas behavior of the gas phase
  - d. latent heat of fusion
  - e. latent heat of vaporization

4. For the substance represented in the diagram, which of the phases is most dense and which is least dense at  $-15\text{ }^{\circ}\text{C}$ ?

Most dense                      Least dense

- |           |        |
|-----------|--------|
| a. Solid  | gas    |
| b. Gas    | liquid |
| c. Solid  | liquid |
| d. Liquid | gas    |
| e. Liquid | solid  |
5. What volume of  $0.18\text{ M HCl}$  is required to neutralize  $25.0\text{ milliliters}$  of  $0.12\text{ M Ba(OH)}_2$ ?
- 22
  - 33
  - 40
  - 60
  - 80



6. The boiling curve above shows how the temperature of a sample varies with time as the sample goes through phase changes. The sample starts as a solid, and heat is added at a constant rate. At which point does liquid first start to appear in the sample?
7. What mass of the compound  $\text{CrO}_3$  ( $\text{MM}=100$ ) contains  $6.3 \times 10^{23}$  oxygen atoms?
- 105 g
  - 95 g
  - 35 g
  - 31 g
  - 12 g

Questions 8-11 refer to the following types of elements in the periodic table.

- A. Lanthanides
- B. Transition Metals
- C. Alkaline earth metals
- D. Halogens

- 8. Ions have smaller radii than regular atoms.
- 9. Are the most easiest to reduce in the given period of the periodic table.
- 10. Show great increase in third ionization energy.
- 11. Electron configuration ends in the orbital with angular momentum quantum number of 3.

12. Which of the following is a correctly balanced nuclear reaction?

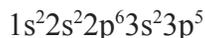
- a.  $Pm_{61}^{145} \rightarrow He_2^4 + Eu_{63}^{149}$
- b.  $Pa_{91}^{231} + 2n_0^1 \rightarrow U_{91}^{232}$
- c.  $H_1^1 + H_1^3 \rightarrow He_2^4 + e_{-1}^0$
- d.  $Fe_{26}^{55} + e_{-1}^0 \rightarrow Mn_{25}^{55}$
- e.  $K_{19}^{40} \rightarrow S_{16}^{40} + 3e_{-1}^0$

13. A radioactive sample of  $^{131}\text{Sn}$  has a half-life of 2 days. In a sample that contains  $3 \times 10^5$  nuclei of  $^{131}\text{Sn}$ , how many beta particles per second will be emitted?

- a.  $19.8 \beta\text{s}^{-1}$
- b.  $8.64 \times 10^5 \beta\text{s}^{-1}$
- c.  $6 \times 10^5 \beta\text{s}^{-1}$
- d.  $25.92 \beta\text{s}^{-1}$
- e.  $262 \beta\text{s}^{-1}$

14. Which cation forms an insoluble iodine and an insoluble sulfide?

- a.  $\text{Ag}^+$
- b.  $\text{Zn}^{2+}$
- c.  $\text{Ba}^{2+}$
- d.  $\text{Fe}^{3+}$
- e.  $\text{Cu}^{2+}$



15. Atoms of element Y have an electron configuration shown above. This element will form which compound with Ca?

- a.  $\text{CaY}$
- b.  $\text{CaY}_2$
- c.  $\text{Ca}_2\text{Y}_3$
- d.  $\text{Ca}_3\text{Y}_2$
- e.  $\text{Ca}_2\text{Y}$

16. What is the half-life of uranium-235?

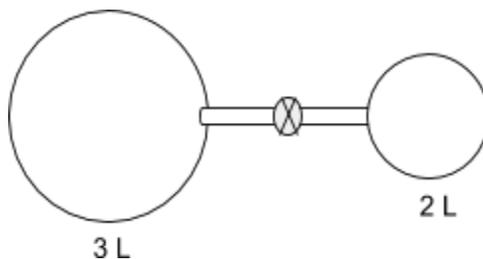
- a. 623 million years
- b. 680 million years
- c. 700 million years
- d. 760 million years
- e. 811 million years

$M(s) + 3Ag^+(aq) \rightarrow 3Ag(s) + M^{3+}(aq)$	$E = +2.46V$
$Ag^+(aq) + e^- \rightarrow Ag(s)$	$E = +0.80V$

17. According to the information above, what is the standard reduction potential for the half-reaction  $M^{3+}_{(aq)} + 3 e^- \rightarrow M_{(s)}$ ?

- a. -1.66V
- b. -0.06V
- c. 0.06V
- d. 1.66V
- e. 3.26V

18. The valve between the 2.00 L bulb, in which the gas pressure is 1.00 atm, and the 3.00 L bulb, in which the gas pressure is 1.50 atm, is opened. (Assume that the valve has a negligible volume.) What is the final pressure in the two bulbs, the temperature remaining constant?



- a. 0.90 atm
- b. 1.25 atm
- c. 1.30 atm
- d. 2.05 atm
- e. 2.25 atm

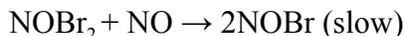
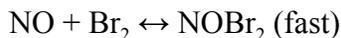
Questions 19-20. Refer to the following mechanisms proposed for the reaction of nitrogen (II) oxide with hydrogen.



19. What is the overall equation for this reaction?
- $\text{NO(g)} + \text{NO(g)} \rightarrow \text{N}_2\text{(g)} + \text{H}_2\text{O(g)}$
  - $2\text{NO(g)} + 2\text{H}_2\text{(g)} \rightarrow \text{N}_2\text{(g)} + 2\text{H}_2\text{O(g)}$
  - $\text{NO(g)} + \text{N}_2\text{O(g)} + \text{H}_2\text{(g)} \rightarrow \text{N}_2\text{(g)} + \text{H}_2\text{O(g)}$
  - $2\text{NO(g)} + 2\text{H}_2\text{(g)} + \text{N}_2\text{O}_2\text{(g)} \rightarrow \text{N}_2\text{O(g)} + \text{N}_2\text{(g)} + 2\text{H}_2\text{O(g)}$
  - $\text{N}_2\text{O}_2\text{(g)} + 2\text{H}_2\text{(g)} \rightarrow \text{N}_2\text{(g)} + 2\text{H}_2\text{O(g)}$
20. Which rate law is consistent with this mechanism?
- rate =  $k[\text{NO}]^2$
  - rate =  $k[\text{N}_2\text{O}][\text{NO}]^2$
  - rate =  $k[\text{NO}]^2[\text{H}_2]$
  - rate =  $k[\text{N}_2\text{O}][\text{H}_2]$
  - rate =  $k[\text{N}_2\text{O}_2][\text{H}_2]$
21. How do the diffusion rates of helium and methane compare at the same temperature?
- Helium diffuses twice as fast as methane.
  - Helium diffuses twice as slow as methane.
  - Helium diffuses four times as fast as methane.
  - Helium diffuses four times as slow as methane.
  - Helium diffuses eight times as fast as methane.
22. Which of the following actions would be likely to change the boiling point of a sample of a pure liquid in an open container?
- Placing it in a smaller container
  - Increasing the number of moles of the liquid in the container
  - Moving the container and liquid to a higher altitude
- I
  - II
  - III
  - II, III
  - I, II, III

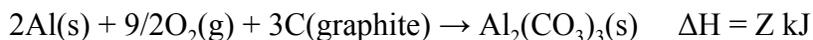
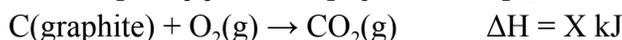


23. The reaction between nitrogen monoxide (commonly called nitric oxide) and bromine is represented above. The proposed reaction mechanism is as follows:



Which of the following reaction mechanisms is consistent with the proposed mechanism?

- Rate =  $k[\text{NO}]^2$
  - Rate =  $k[\text{NO}][\text{Br}_2]$
  - Rate =  $k[\text{NO}][\text{Br}_2]^2$
  - Rate =  $k[\text{NO}]^2[\text{Br}_2]$
  - Rate =  $k[\text{NO}]^2[\text{Br}_2]^2$
24. Which of the following is the change in enthalpy for the following reaction given below?



- X+Y+Z
- 2X+3Y-1/2Z
- 3X+Y-Z
- 3X-2Y+Z
- 3X+1/2Y-Z

Experiment	Initial [NO] (mol/L)	Initial [O <sub>2</sub> ] (mol/L)	Initial rate of formation of NO <sub>2</sub> (mol/L · s)
1	0.1	0.1	$2.5 \times 10^{-4}$
2	0.2	0.1	$5.0 \times 10^{-4}$
3	0.2	0.4	$8.0 \times 10^{-3}$

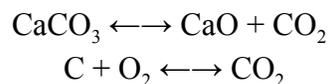
The data showing initial rate is shown on the table given above. The reaction that the data was obtained from is expressed below.



25. What is the experimental rate law for the reaction?

- rate =  $k[\text{NO}][\text{O}_2]$
- rate =  $k[\text{NO}][\text{O}_2]^2$
- rate =  $k[\text{NO}]^2[\text{O}_2]$
- rate =  $k[\text{NO}]^2[\text{O}_2]^2$
- rate =  $k[\text{NO}][\text{O}_2]^3$

26. The decomposition shown below is a nonspontaneous with a  $\Delta G^\circ = 130\text{kJ}$ . The reaction can be coupled with the reaction between solid C and oxygen gas to form carbon dioxide, which has  $\Delta G^\circ = -390\text{kJ}$ .



Based on Le Chatelier's principle, which of the following changes would make the coupled reaction nonspontaneous?

- Decrease the pressure
  - Increase the amount of carbon and oxygen with fixed amount of calcium carbonate.
  - Increase the amount of calcium carbonate with limited amount of carbon and oxygen gas.
  - Add catalyst
  - Decrease the amount of calcium oxide.
27. What product results when 2-butene reacts with chlorine?
- 2-chlorobutane
  - 2,3-dichlorobutane
  - 2,2-dichlorobutane
  - 1,2-dichlorobutane
  - 2,2,3-trichlorobutane
28. Which of the following is the carbon atom to carbon atom length in the ethyne ( $\text{C}_2\text{H}_2$ ) molecule, based on the following data?

Atom	Atomic Radius (pm)
H	37
C <sub>single</sub>	77
C <sub>double</sub>	67
C <sub>triple</sub>	60
N <sub>double</sub>	62
N <sub>triple</sub>	55
O <sub>double</sub>	61
O <sub>triple</sub>	56

- 30
- 60
- 67

- d. 120  
e. 127
29. The safest and most effective emergency procedure to treat an acid splash on skin is to do which of the following immediately?
- Rinse the affected area with distilled water and use paper towel to dry the area
  - Sprinkle the affected area with powdered  $\text{Na}_2\text{SO}_4(\text{s})$
  - Flush the affected area with water and then with a dilute  $\text{NaHCO}_3$  solution
  - Flush the affected area with water and then with a dilute vinegar solution
  - Flush the affected area with water and then with a dilute  $\text{Ba}(\text{OH})_2$  solution
30. Which of the following is the correct equilibrium expression for the hydrolysis of  $\text{CO}_3^{2-}$  ?
- $K = [\text{HCO}_3^-] / ([\text{CO}_3^{2-}] [\text{H}_3\text{O}^+])$
  - $K = ([\text{CO}_3^{2-}] [\text{OH}^-]) / [\text{HCO}_3^-]$
  - $K = ([\text{CO}_3^{2-}] [\text{H}_3\text{O}^+]) / [\text{HCO}_3^-]$
  - $K = ([\text{HCO}_3^-] [\text{OH}^-]) / [\text{CO}_3^{2-}]$
  - $K = [\text{CO}_3^{2-}] / ([\text{CO}_2] [\text{OH}^-]^2)$
31. A substance is added to a solution containing two drops of phenolphthalein. The solution then turns pink. Which substance would produce this color change?
- HCl
  - $\text{H}_2\text{CO}_3$
  - KOH
  - $\text{CH}_3\text{OH}$
  - $\text{CH}_3\text{CH}_2\text{OH}$
32. Which of the following processes would be the best method for determining the unknown concentration of a known ionic solution?
- Using pH paper and calculating concentration using the relationship between [H and molarity of ions solution.
  - Measuring the partial pressure of the substance, and calculating concentration using Dalton's law.
  - Evaporation of the water of a known volume of solution, the massing of the solid, and calculation concentration using moles of the substance divided by the volume of the solution.
  - Titration with a common ion of known concentration and calculating concentration with molarity and volume relationship.
  - Using the spectrophotometry to measure the absorbance and employ the relationship between absorbance and the concentration to determine the concentration.

Questions 33-37. Select the correct geometric structure for each of the molecules.

- A. Square planar
- B. Tetrahedral
- C. Trigonal Bipyramidal
- D. Octahedron
- E. Trigonal Pyramid

33. Sulfur tetrafluoride

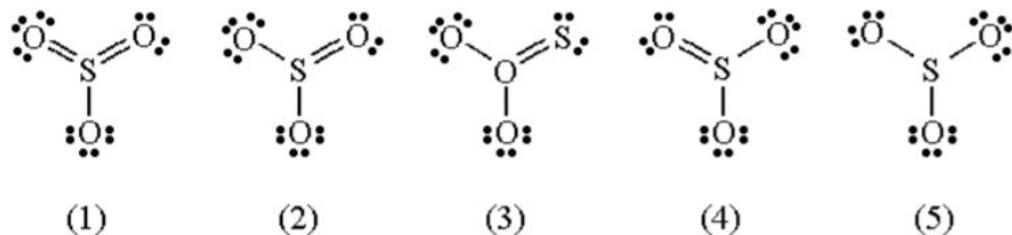
34. Phosphorus pentachloride

35. Bromine pentafluoride

36. Xenon tetrafluoride

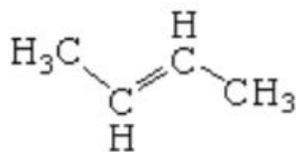
37. Ammonia

38. Which of the following are correct resonance structures of  $\text{SO}_3$ ?



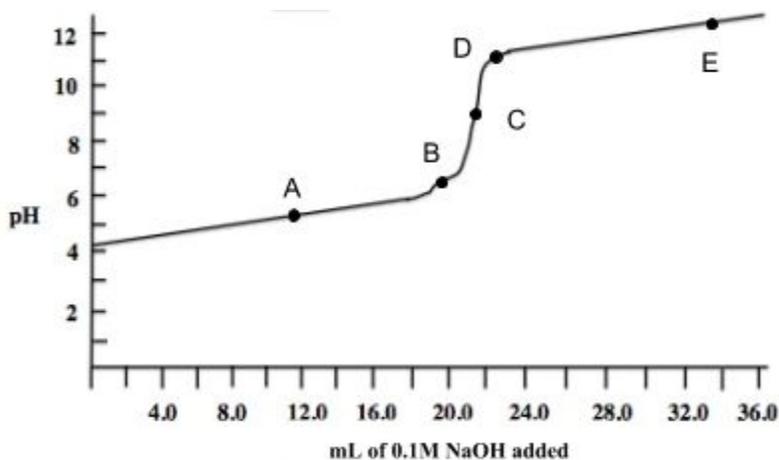
- a. 1, 5
  - b. 2, 3
  - c. 2, 4
  - d. 1, 3, 5
  - e. 1, 2, 4
39. Carbon-14 has a half life of 5700 years. How old is a wooden object if 60% of the  $^{14}\text{C}$  has decayed?
- a.  $\frac{\ln(100/40)}{(\ln(2)/5730)}$
  - b.  $\frac{\ln(100/60)}{(\ln(2)/5730)}$
  - c.  $\frac{\ln(40/100)}{(\ln(2)/5730)}$
  - d.  $\frac{\ln(60/100)}{(\ln(2)/5730)}$
  - e.  $\frac{\ln(100/40)}{(5730/\ln(2))}$

40. How many sigma and pi bonds are present in the following molecule?



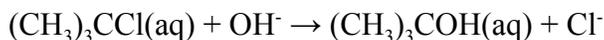
- a. 8 sigma, 2 pi  
 b. 9 sigma, 3 pi  
 c. 10 sigma, 1 pi  
 d. 11 sigma, 1 pi  
 e. 11 sigma, 2 pi
41. Given the following, which one is paramagnetic?
- a.  $\text{N}_2$   
 b.  $\text{O}_2$   
 c.  $\text{F}_2$   
 d.  $\text{Li}_2$   
 e.  $\text{H}_2$
42. A saturated solution of which salt will have the second highest  $[\text{Ag}^+]$ ?
- a.  $\text{AgBr}$  ( $K_{\text{sp}} = 5 \times 10^{-13}$ )  
 b.  $\text{AgI}$  ( $K_{\text{sp}} = 8.5 \times 10^{-17}$ )  
 c.  $\text{Ag}_2\text{SO}_4$  ( $K_{\text{sp}} = 1.2 \times 10^{-5}$ )  
 d.  $\text{Ag}_3\text{PO}_4$  ( $K_{\text{sp}} = 1.8 \times 10^{-18}$ )  
 e.  $\text{Ag}_2\text{CO}_3$  ( $K_{\text{sp}} = 8.2 \times 10^{-12}$ )

Questions 43-45. The graph below shows the titration curve that results when 100. mL of 0.0250 M acetic acid is titrated with 0.100 M NaOH.



43. Consider the points labeled (A) through (E). Which one is the point at which the concentrations of the weak acid and its conjugate base are approximately equal?

44. What part of the curve corresponds to the optimum buffer action for the acetic acid/acetate pair?
- A
  - Section between AB
  - C
  - Section between DE
  - E
45. Which of the following indicators is the best choice for this titration?
- |    | Color range      | pH range    |
|----|------------------|-------------|
| a. | Methyl orange    | 3.2 - 4.4   |
| b. | Methyl red       | 4.8 - 6.0   |
| c. | Bromothymol blue | 6.1 - 7.6   |
| d. | Phenolphthalein  | 8.2 - 10.0  |
| e. | Alizarin         | 11.0 - 12.4 |
46. Which of the following expressions is correct for the maximum mass of copper, in grams, that could be plated out by electrolyzing aqueous  $\text{CuCl}_2$  for 16 hours at a constant current of 3.0 amperes? (1 faraday = 96,500 coulombs)
- $[(16)(3,600)(3.0)(63.55)(2)] / (96,500)$
  - $[(16)(3,600)(3.0)(63.55)] / (96,500)$
  - $[(16)(3,600)(3.0)(63.55)] / [(96,500)(2)]$
  - $[(16)(60)(3.0)(96,500)] / [(63.55)(2)]$
  - $[(16)(60)(3.0)(96,500)(2)] / (63.55)$
47. Find the molar solubility of silver chromate in water at 25 °C. ( $K_{\text{sp}} = 1.2 \times 10^{-12}$ )
- $(0.3 \times 10^{-12})^{1/2}$
  - $(0.4 \times 10^{-12})^{1/2}$
  - $(0.3 \times 10^{-12})^{1/3}$
  - $(0.4 \times 10^{-12})^{1/3}$
  - $(0.5 \times 10^{-12})^{1/3}$
48. The chloromethane molecule has which of the following hybridizations and polarities?
- $\text{sp}^3$ , polar
  - $\text{sp}^3$ , nonpolar
  - $\text{sp}^2$ , polar
  - $\text{sp}^2$ , nonpolar
  - $\text{s}^2\text{p}^2$ , polar



For the reaction represented above, the experimental rate law is given as follows.

$$\text{rate} = k[(\text{CH}_3)_3\text{CCl}]$$

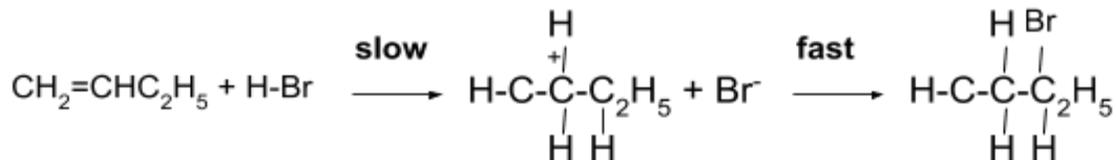
49. If some solid sodium hydroxide is added to a solution that is 0.010M in  $(\text{CH}_3)_3\text{CCl}$  and 0.10M in NaOH, which of the following is true? (Assume the temperature and volume remain constant.)
- both the reaction rate and  $k$  increase
  - both the reaction rate and  $k$  decrease
  - both the reaction rate and  $k$  remain the same.
  - the reaction rate increases but  $k$  remains the same.
  - the reaction rate decreases but  $k$  remains the same.

$$\text{rate} = k[\text{X}]$$

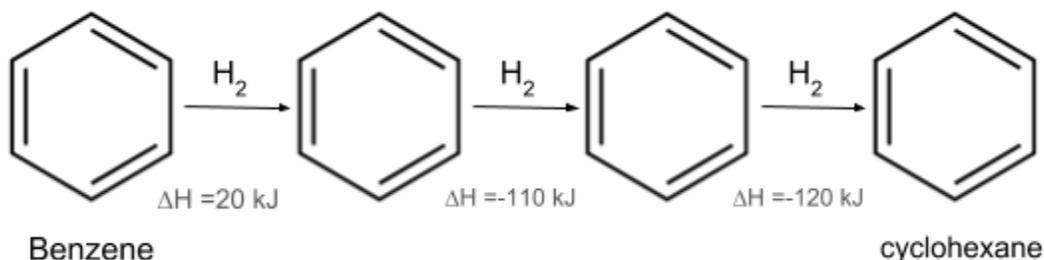
50. For the reaction whose rate law is given above, a plot of which of the following is a straight line?
- $[\text{X}]$  vs time
  - $\log[\text{X}]$  vs time
  - $1/[\text{X}]$  vs time
  - $\log[\text{X}]$  vs  $1/\text{time}$
  - $1/[\text{X}]$  vs  $\log(\text{time})$

## Free Response Questions

1. The reaction between alkene and hydrobromic acid proceeds via a slightly exothermic two step reaction.



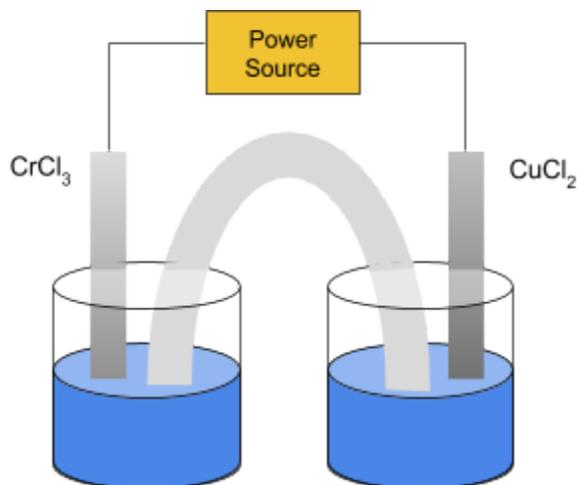
- a. With the mechanism given above:
- Draw an energy graph for the reaction.
  - Write a rate law for the reaction.



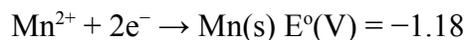
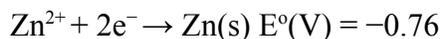
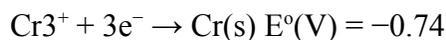
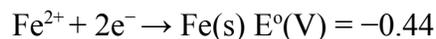
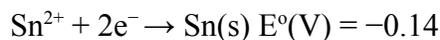
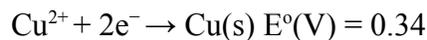
- b. The hydrogenation of benzene to form cyclohexane, in the presence of a nickel catalyst at 500 K proceeds via the following multi-step reaction. Refer to the multi-step reaction process above to answer the questions.
- Calculate the total enthalpy for the reaction based on one mole of reactant.
  - The same reaction is carried out at 250 K with an experimental enthalpy change of -360 kJ/mol. The free energy for the reaction at the higher temperature is three times that of the one at the lower temperature with a negligible entropy change. Calculate the relative entropy for the reaction in kJ/mol•K.
  - Would the reaction be spontaneous in the presence of a metal catalyst at 125 K with an enthalpy change of -430 kJ/mol? Explain.







2. The above cell was used set up with 1.00M  $\text{CrCl}_3$  in one compartment and 1.00M  $\text{CuCl}_2$  in the other. The standard cell potentials of various metals are shown below.



- Calculate the standard cell potential of the above system at 1 atm and 25°C
- A chemist wants to develop a metallic coating for an iron structure that will not rust when exposed to the environment and will not darken or drastically change the color of the metal alloy.
  - Based on the above information, which metal, zinc or tin, could be used to successfully coat the iron structure in a galvanic set-up? Explain your answer.
  - WRITE THE STOICHIOMETRIC ANALYSIS BUT DO NOT SOLVE. The experiment is allowed to run for 125.0 minutes at 3.50 amps. How many grams of the chosen metal were successfully plated onto the iron structure?
  - A system has an emf value of 0.05 V with three electrons transferred per mole during the reaction. What is the change in enthalpy in kJ/mol for the system at 27.0°C when the change in entropy is  $-0.02 \text{ J/mol} \cdot \text{K}$ ?





When performing the trials, the student changed concentrations of the reactants and let the reaction run for 400 seconds each trial. For Experiment 4, the student forgot to write down the initial concentration of X. The table of results is given below.

Experiment	[X] (mol/L)	[Y] (mol/L)	Initial Rate (mol/L · s)
1	0.100	0.100	$2.50 \times 10^{-4}$
2	0.300	0.100	$2.25 \times 10^{-3}$
3	0.300	0.200	$2.25 \times 10^{-3}$
4		0.200	$9.00 \times 10^{-3}$

- What is the rate expression for this reaction? Show all calculations.
- Calculate the value of k for this reaction with correct units.
- Calculate the initial concentration for Experiment 4 (in mol/L).
- Complete the following data table with the correct remaining concentration after 400 seconds has passed in the experiment. Justify with calculations.

Concentration (mol/L)	Time (s)
0.100 M	0
	400

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