ABBREVIATIONS AND SYMBOLS

ampere	A	Faraday constant	F	molal	m
atmosphere	atm	formula molar mass	M	molar	M
atomic mass unit	u	free energy	G	molar mass	M
atomic molar mass	A	frequency	ν	mole	mol
Avogadro constant	N_A	gas constant	R	Planck's constant	h
Celsius temperature	°C	gram	g	pressure	P
centi– prefix	c	heat capacity	C_p	rate constant	k
coulomb	C	hour	h	retention factor	R_f
electromotive force	E	joule	J	second	s
energy of activation	E_a	kelvin	K	temperature, K	T
enthalpy	H	kilo– prefix	k	time	t
entropy	S	liter	L	volt	V
equilibrium constant	K	milli– prefix	m		

CONSTANTS

$R = 8.314\ \text{J·mol}^{-1}\text{·K}^{-1}$

$R = 0.0821\ \text{L·atm·mol}^{-1}\text{·K}^{-1}$

$1\ F = 96{,}500\ \text{C·mol}^{-1}$

$1\ F = 96{,}500\ \text{J·V}^{-1}\text{·mol}^{-1}$

$N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$

$h = 6.626 \times 10^{-34}\ \text{J·s}$

$c = 2.998 \times 10^{8}\ \text{m·s}^{-1}$

$0\ °\text{C} = 273.15\ \text{K}$

$1\ \text{atm} = 760\ \text{mmHg}$

EQUATIONS

$$E = E° - \frac{RT}{nF}\ln Q$$

$$\ln K = \left(\frac{-\Delta H}{R}\right)\left(\frac{1}{T}\right) + \text{constant}$$

$$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

PERIODIC TABLE OF THE ELEMENTS

1 1A												13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H 1.008	2 2A																2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (277)		114 (???)				

58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0

DIRECTIONS

- When you have selected your answer to each question, blacken the corresponding space on the answer sheet using a soft, #2 pencil. Make a heavy, full mark, but no stray marks. If you decide to change an answer, erase the unwanted mark very carefully.
- This is a single use exam, so you may make marks in the test.
- There is only one correct answer to each question. Any questions for which more than one response has been blackened **will not be counted**.
- Your score is based solely on the number of questions you answer correctly. **It is to your advantage to answer every question.**

1. The allotrope of carbon shown to the right is:

   (A) buckminsterfullerene (B) graphite (C) nanotuberite (D) diamond

2. The members of this class of minerals include the majority of ores from which metals are obtained.

   (A) the halides (B) the sulfides (C) the silicates (D) the oxides

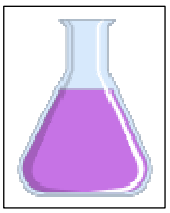
3. In flame testing the element whose color is blue-green (often with white flashes) in a flame is

   (A) potassium (B) strontium (C) calcium (D) copper

4. Balance the equation. What is the sum of the coefficients of the **balanced** equation?

   _____CN^- + _____OH^- + ____$Cu(NH_3)_4^{2+}$ → _____$Cu(CN)_3^{2-}$ + _____NH_3 + _____CNO^- + _____H_2O

   (A) 8 (B) 14 (C) 23 (D) 28

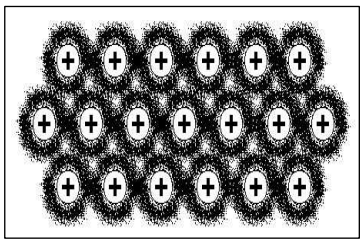


5. Teachers really like it when you know the name of a piece of glassware that you need or just broke. And conversely, teachers may become irritated if you ask for "one of those glass things used in this experiment." The correct name for the item shown on the right is

   (A) an Erlenmeyer flask (B) a Griffin beaker (C) a Soxhlet bottle (D) a Gooch crucible

6. Mothballs can be made from one of the chemicals listed below. What is the composition of a commercial product if a solution of 100.0 g of ethanol containing 5.00 g mothballs boils at 78.77°C? The boiling point of pure ethanol is 78.41°C. K_b(ethanol) is 1.22°C mol^{-1}.

   (A) naphthalene, $C_{10}H_8$ (molar mass 128 g).
   (B) para-dichlorobenzene, $C_6H_4Cl_2$ (molar mass 147 g).
   (C) camphor, $C_{10}H_{16}O$ (molar mass 168 g).
   (D) chlorothalonil, $C_8Cl_4N_2$, (molar mass 265 g).



7. The figure shown in the right represents

   (A) a metallic solid (B) an ionic solid.
   (C) a covalent network solid (D) a molecular solid

8. Silver crystallizes in a face-centered cubic unit cell with edge length 4.073×10^{-8} cm. The molar mass of silver is 107.87 g. From this data calculate the density of silver in g/cm^3. Avogadro's Number = 6.0223×10^{23}

   (A) 2.650 g/cm^3 (B) 5.299 g/cm^3 (C) 10.18 g/cm^3 (D) 10.60 g/cm^3

9. How many grams of copper will dissolve if 10.0 g of Cu pellets are mixed in 100 mL of 1.0 M HCl? (Cu = 63.55 g/mole, HCl = 36.45 g/mole)

   (A) 0.0 g (B) 3.18 g (C) 6.36 g (D) 10.0 g

10. Based on the table below, find the enthalpy of decomposition for the reaction:

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

    (A) -98 kJ (B) -196 kJ
    (C) -632 kJ (D) -692 kJ

Enthalpy of formation of $H_2O_2(l)$	ΔH^f_o = -188 kJ/mole
Enthalpy of formation of $H_2O(l)$	ΔH^f_o = -286 kJ/mole
Enthalpy of dissociation for $O_2(g) \rightarrow 2O(g)$	ΔH= -496 kJ/mole
Enthalpy of dissociation for $H_2(g) \rightarrow 2H(g)$	ΔH= -436 kJ/mole

11. When $H_2O_2(aq)$ decomposes, the products are H_2O and $O_2(g)$, as given by the balanced equation:

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

    A student decomposes an aqueous solution containing 2.00 g of H_2O_2 (molar mass = 34.0 g) and collects 0.75 grams of O_2 gas. (molar mass = 32.0 g). The student's percent yield is:

    (A) 20% (B) 35% (C) 40% (D) 80%

12. In the reaction in problem 11, a student decomposes an aqueous solution containing 2.00 g of H_2O_2 (molar mass = 34.0 g) and collects the O_2 gas <u>over</u> water at 27ºC and 757 torr pressure. The vapor pressure of water at 27ºC is 27 torr. The theoretical volume of oxygen the student collected in mL was (R = 0.0821 atm·L /mole·K)

    (A) 730 mL (B) 750 mL (C) 1450 mL (D) 1510 mL

13. Choose a name-formula pair that does **<u>not</u>** correctly match.

    (A) perchloric acid = $HClO_4$ (B) iron(II) carbonate = $IrCO_3$
    (C) silver nitrate = $AgNO_3$ (D) sulfurous acid = H_2SO_3

14. The K_{sp} values for $Cu(OH)_2$ and $Mn(OH)_2$ are 4.8×10^{-20} and 1.6×10^{-13} respectively. The best pH to separate a mixture that is 0.10 M in both Cu^{2+} and Mn^{2+} is

    (A) 4.0 (B) 6.0 (C) 8.0 (D) 10.0

15. Which of the following has the same number of grams of oxygen as 49 grams of sulfuric acid, H_2SO_4? (S = 32.0, H=1.0, O = 16.0), Avogadro's number = 6.02×10^{23}

    (A) 45 grams of H_2O
    (B) 1.2×10^{24} moles of H_2O_2
    (C) 6.0×10^{22} moles of SO_2
    (D) 0.67 moles of SO_3

16. For the reaction: $2CHCl_3(l) + O_2(g) \rightarrow 2COCl_2(g) + 2HCl(g)$ $\Delta H_{rxn} = -366$ kJ and $\Delta S_{rxn} = +340$ J/K.

Is the formation of the poisonous gas phosgene, $COCl_2$ spontaneous at 25°C? (R = 8.31 J/K·mol)

(A) Yes. The reaction is spontaneous.
(B) The reaction does not occur but would with an increase in temperature.
(C) The reaction does not occur but would with an increase in pressure.
(D) The reaction will never occur under any conditions.

17. From the following given enthalpies of reaction find ΔH° in kJ/mol of reaction for this reaction:

$H_2(g) + Cl_2(g) \rightarrow 2\ HCl(g)$

$NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$	ΔH° = -176. kJ/mol
$N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$	ΔH° = -92. kJ/mol
$N_2(g) + 4\ H_2(g) + Cl_2(g) \rightarrow 2\ NH_4Cl(s)$	ΔH° = -629. kJ/mol

(A) -93 kJ/mol (B) -185 kJ/mol (C) -361 kJ/mol (D) -767 kJ/mol

18. The number of unpaired electrons in the gaseous Co^{2+} ion is:

(A) 1 (B) 3 (C) 5 (D) 7

19. When Co^{2+} is coordinated with Cl^-, the tetrahedral complex $CoCl_4^{2-}$ results. The number of unpaired electrons in the complex is:

(A) 1 (B) 3 (C) 5 (D) 7

20. An element A is a component in compound X that contains only hydrogen and element A. Element A is

(A) C (B) O (C) Si (D) P

Compound	% A by mass	Density of gas STP
X	90.28	2.78 g/L

Questions 21 and 22 deal with the electrochemical cell described below. The Nernst equation is:

$$E_{cell} = E° - \frac{0.0592}{n} \log Q$$

21. The following cell is made: The cathode is an inert Pt strip dipped in a 1.0 M aqueous solution of H_2O_2 solution mixed with 1.0 M HCl. The anode is a Ag strip dipped in a 1.0 M solution of KCl. Immediately AgCl forms on its surface. A salt bridge is inserted between the two half cell solutions and a voltmeter connects the two electrodes. The schematic is given below.

$Ag(s)|AgCl(s)|Cl^-(1.0\ M)||H_2O_2(1.0\ M), H^+(1.0\ M)\ |Pt(s)$

$H_2O_2(aq) + 2H^+ + 2e^- \rightarrow 2H_2O$	$E^o = 1.76$ V
$AgCl(s) + e^- \rightarrow Ag(s) + Cl^-(aq)$	$E^o = 0.22$ V

The cell potential at 25°C for the cell is

(A) -1.98 V (B) -1.54 V (C) 1.54 V (D) 1.98 V

22. In the above cell, solid NaOH is added to the cathode and stirred until it dissolves in the H_2O_2 solution. After cooling to 25°C, the cell potential drops 0.30 V. Assuming no change is volume and decomposition of the H_2O_2, the pH of the cathode is:

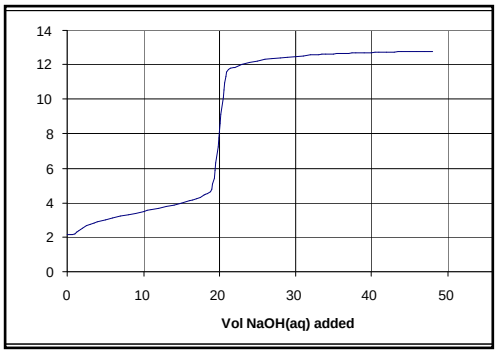
(A) 2.6 (B) 5.1 (C) 7.0 (D) 8.1

23. For the reaction below, a mixture with the following concentrations: [HI] = 2.0 M, [H_2] = 0.50 M and [I_2] = 0.10 M was put into a vessel. Which one of the following statements is **TRUE** for the system?

$$2HI(g) \rightleftarrows H_2(g) + I_2(g) \qquad K_c = 0.020.$$

(A) Q_c is greater than K_c; more H_2 and I_2 will be produced.
(B) Q_c is greater than K_c; more HI will be produced.
(C) Q_c is less than K_c; more HI will be produced.
(D) Q_c is less than K_c; more H_2 and I_2 will be produced.

Questions 24 and 25 deal with the titration curve shown.



24. The plot to the right shows the pH vs. amount of base during the titration of 20.0 mL of 0.10 M weak acid, HA with 0.10 M NaOH. From the titration curve, the weak acid is

(A) nitrous acid, HNO_2, $K_a = 7.1 \times 10^{-4}$
(B) formic acid, HCOOH, $K_a = 1.8 \times 10^{-4}$
(C) acetic acid, $HC_2H_3O_2$, $K_a = 1.8 \times 10^{-5}$
(D) KHP, $KC_8H_5O_4$, $K_a = 3.9 \times 10^{-6}$

25. In the titration, what sort of calculation would you use to find the pH after 25.0 mL of NaOH has been added?

(A) Treat it as excess strong base; use K_b and adjust for the final volume.
(B) Treat it as buffer problem; use K_a or K_b or Henderson-Hasselbalch equation.
(C) Treat it as excess strong base; do not use K_a or K_b.
(D) Treat it as pure weak acid; use K_a and adjust for the final volume.

26. A coffee-cup calorimeter contains 50.0 g of water at 23.0°C. A 25.0 g block of metal is heated to 100.0°C and placed in the water in the calorimeter. The contents of the calorimeter reach an equilibrium temperature of 25.0°C. No energy is lost to the calorimeter or the surroundings. Identify the metal from its literature value of the specific heat capacity. Specific heat of water = 4.18 J/g·°C.

(A) Pb = 0.128 J/g·°C (B) Ag = 0.233 J/g·°C (C) Zn = 0.387 J/g·°C (D) Fe = 0.448 J/g·°C

27. In the balanced equation below, the particle X is:

$$^{249}_{98}\mathrm{Cf} + ^{12}_{6}\mathrm{C} \rightarrow ^{257}_{104}\mathrm{Rf} + 4\mathrm{X}$$

(A) $^{1}_{1}\mathrm{H}$ (B) $^{4}_{2}\mathrm{He}$ (C) $^{1}_{0}\mathrm{n}$ (D) $^{0}_{-1}e$

28. Calculate the K_{sp} for calcium carbonate, $CaCO_3$ in water at 298 K. Use R = 8.31 J/mole·K

$$CaCO_3(s) \rightleftarrows Ca^{2+}(aq) + CO_3^{2-}(aq)$$

(A) 9.0×10^{-14} (B) 3.3×10^{-9}
(C) 5.8×10^{-2} (D) 3.1×10^{6}

	ΔH^o(kJ/mole)	S^o(J/(mole·K)
$CaCO_3(s)$	-1207	93
$Ca^{2+}(aq)$	-543	-53
$CO_3^{2-}(aq)$	-677	-60

29. When 15 mL of 0.0025 M HCl is added to 135 mL of distilled water, the pH of the mixture is

(A) 1.43 (B) 2.60 (C) 3.56 (D) 3.60

30. Which bond properties are consistent with one another?

	Bond Order	Bond Length	Bond Strength
(A)	higher	shorter	higher
(B)	higher	longer	lower
(C)	lower	shorter	lower
(D)	lower	longer	higher

31. For the reaction of the decomposition of water: $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$, what temperature will this reaction first become spontaneous? (Assume ΔH and ΔS are independent of temperature.)

(A) It will never be spontaneous.
(B) It will always be spontaneous.
(C) 1760 K
(D) 5900 K

	ΔH(kJ/mole)	ΔS(J/mole·K)
$H_2O(g)$	-286	70
$H_2(g)$	0	130
$O_2(g)$	0	205

32. Which of the following is appropriate for laboratory safety?

(A) No unauthorized experiments are to be performed.
(B) Never taste anything. Never directly smell the source of any vapor or gas; instead by means of your cupped hand, waft a small sample to your nose.
(C) Notify the instructor immediately in case of an accident.
(D) All of the above are appropriate for laboratory safety.

33. The best indicator is for titrating a 0.100 M solution of NH_3 ($K_b = 1.8 \times 10^{-5}$) with 0.100 M HNO_3 is

	Indicator	pH Range
(A)	Methyl red	4.8 – 6.0
(B)	Bromothymol blue	6.0 - 7.6
(C)	Phenolphthalein	8.3 - 9.9
(D)	Alizarin yellow	10.1-12.0

34. Acid rain is primarily due to the presence of sulfuric acid, H_2SO_4, in rain water When a 500.0 mL sample of acid rain is titrated, 1.00 mL of 0.0500 M NaOH is required to reach the end point. The pH of the original acid rain solution is

$$H_2SO_4(aq) + 2\ NaOH(aq) \rightarrow Na_2SO_4(aq) + 2\ H_2O(l)$$

(A) 1.3 (B) 3.0 (C) 4.0 (D) 4.3

35. From the periodic table the atomic mass of Cl is 35.453. About 75% of all Cl atoms are ^{35}Cl. If there is only one other common isotope, it is most likely to be

(A) ^{36}Cl (B) ^{37}Cl (C) ^{38}Cl (D) $^{35.453}Cl$

Problems #36 and #37 deal with the following mechanism:

Step 1:	$Cl_2(g) \rightleftarrows 2\ Cl(g)$	(fast)
Step 2:	$Cl(g) + CHCl_3(g) \rightarrow HCl(g) + CCl_3(g)$	(slow)
Step 3:	$Cl(g) + CCl_3(g) \rightarrow CCl_4(g)$	(fast)

36. What is the overall reaction?
    (A) $Cl_2(g) + CHCl_3(g) \rightarrow HCl(g) + CCl_4(g)$
    (B) $Cl(g) + CHCl_3(g) \rightarrow HCl(g) + CCl_3(g)$
    (C) $2\ Cl(g) + CHCl_3(g) \rightarrow HCl(g) + CCl_4(g)$
    (D) $HCl(g) + CCl_4(g) \rightarrow Cl_2(g) + CHCl_3(g)$

37. What is the rate law predicted by the mechanism?

    (A) Rate = $[CHCl_3]\ [Cl_2]$ (C) Rate = $[Cl][CHCl_3]$
    (B) Rate = $[CHCl_3]\ [Cl_2]^{1/2}$ (D) Rate = $[Cl_2]$

38. The reaction below shows the decomposition of methanol. $K_C = 1.26 \times 10^{-3}$.

$$CH_3OH(g) \rightleftarrows CO(g) + 2H_2(g)$$

    At equilibrium, flask contains $CH_3OH = 0.25$ M and CO = 0.060 M. What is the concentration of H_2?

    (A) 0.00030 M (B) 0.0053 M (C) 0.017 M (D) 0.072 M

39. Which 0.1 M cation solution will precipitate with 0.1 M solutions of all of these anions; S^{2-}, CO_3^{2-}, SO_4^{2-}?

    (A) NH_4^+ (B) Fe^{3+} (C) Mg^{2+} (D) Pb^{2+}

40. A lab analyzes two samples of a drug, sample A and sample B. Sample A is crystalline and several microscopic samples taken from different points in A are indistinguishable; all properties of the material seem uniform. Sample B has a slightly different color than A. Chromatography resolves B into separate components. Based on these observations, which conclusions are true?

.

    I. Sample A is a pure substance.
    II. Sample B is a mixture.
    III. Sample A is homogeneous.

    (A) II and III (B) I and II. (C) I and III (D) I, II, and III

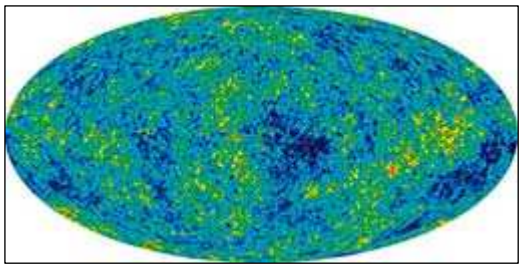
41. How was most of the zinc in the Universe produced?

    (A) In the core of stars through fusion.
    (B) In nuclear decay of radioactive elements.
    (C) In supernovae explosions.
    (D) In the "Big Bang."

42. The half-life of ^{14}C is 5730 years. A wood sample from a living tree has a ^{14}C activity of 0.255 Bq, What will be its activity after 10,000 years?

    (A) 0.15 Bq (B) 0.17 Bq (C) 0.11 Bq (D) 0.076 Bq

43. The satellite image shown on the right is



(A) a picture of the infant universe
(B) the Milky Way.
(C) the Earth as seen in infrared radiation.
(D) a supernova explosion.

44. What is the approximate molar mass of an unknown if a 500 mL aqueous solution containing 0.25 g of the unknown at 27°C has an osmotic pressure of 4.7 mm Hg?

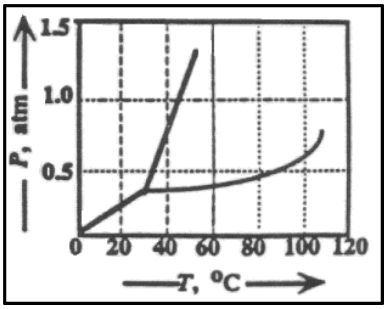
(A) 200 g/mole (B) 2000 g/mole (C) 20,000 g/mole (D) 200,000 g/mole

45. The pH that results when the following three solutions are mixed is: (The pK_a for hypochlorous acid is 7.53.)

(A) 6.93 (B) 7.23 (C) 7.83 (D) 8.13

50 mL	0.20 M	hypochlorous acid (HOCl)
25 mL	0.10 M	sodium hypochlorite (NaOCl)
400 mL		water (H_2O)

46. What phase change will occur in the substance represented in the phase diagram when the temperature and pressure are changed from 20°C and 0.5 atm to 80°C and 0.20 atm



(A) liquid to solid (B) gas to solid (C) solid to liquid (D) solid to gas

47. A 25.00 g cadmium electrode in a solution of $CdSO_4$, functioning as the cathode, is used in a galvanic cell with Zn in a solution of $ZnSO_4$ as the anode. A current of 1.50 A flows for 3.05 hours. What is the mass of the Cd electrode at that time? (atomic mass Cd =112.4), *F*= 96500, 1 hour = 3600 s
(A) 9.59 g (B) 15.41 g (C) 19.18 g (D) 34.59 g

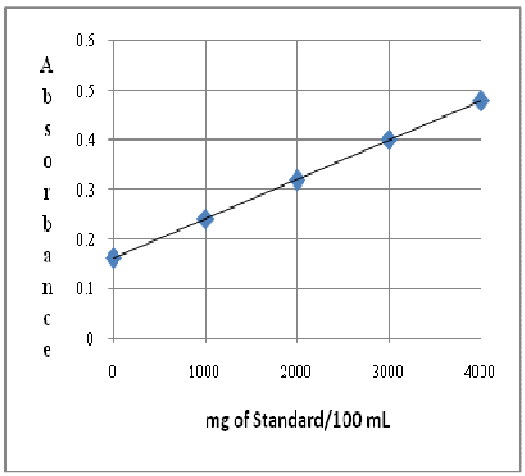
48. In the alkaline battery the overall reaction is:

$$Zn(s) + 2MnO_2(s) + 2\ H_2O \rightarrow Zn(OH)_2(s) + 2MnO(OH)(s)$$

Which of the following half-reactions is taking place at the anode?

(A)	$2\ MnO_2(s) + 2\ H_2O + 2e \rightarrow 2\ MnO(OH)(s) + 2\ OH^-(aq)$
(B)	$Zn(s) + 2\ OH^-(aq) \rightarrow Zn(OH)_2(s) + 2e^-$
(C)	$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$
(D)	$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$

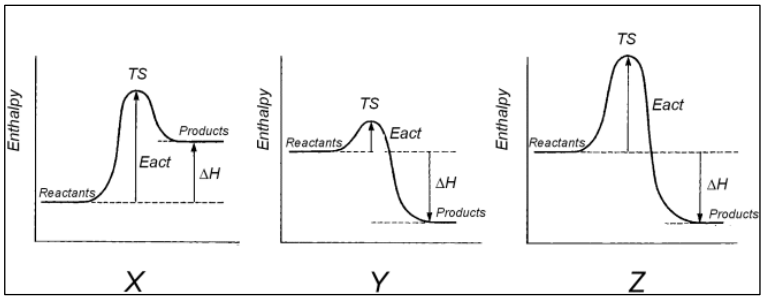
49. The unknown containing element Z was mixed with aliquots of a standard solution of Z as shown in the table. When analyzed, the mixtures gave the absorbance readings listed. When plotted, the graph to the right resulted. The equation for the line is y = (8.00 x 10^{-5}) x + 0.162. The concentration of Z in the unknown is



Vol. of unknown	µg of standard	Total Vol.	Absorbance
10.00 mL	0 mg	100.0 mL	0.163
10.00 mL	1000 mg	100.0 mL	0.240
10.00 mL	2000 mg	100.0 mL	0.319
10.00 mL	3000 mg	100.0 mL	0.402
10.00 mL	4000 mg	100.0 mL	0.478

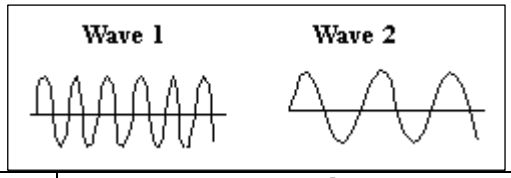
(A) 8 x 10^{-5} µg/mL
(B) 1.6 µg/mL
(C) 200 µg/mL
(D) 2000 µg/mL

50. In the reaction profiles to the right, which reactions have endothermic activation energies?



(A) X only.
(B) Y only.
(C) Y and Z only.
(D) None.

51. Which of the following is true in comparing these two waves in the electromagnetic spectrum is correct?



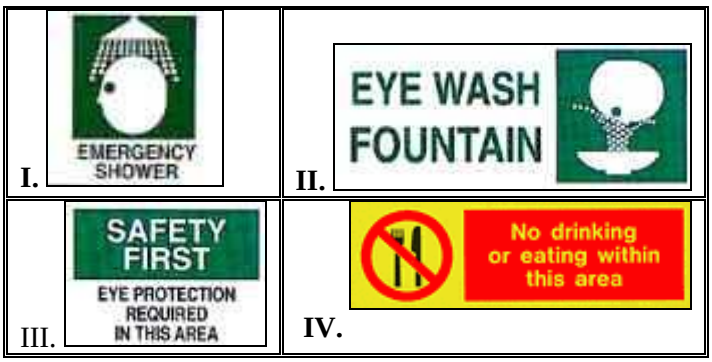
	Wavelength	Frequency	Speed
(A)	Wave 1 longer than Wave 2	Wave 1 lower than Wave 2	Wave 1 has the same speed as Wave 2
(B)	Wave 1 longer than Wave 2	Wave 1 lower than Wave 2	Wave 1 is faster than Wave 2
(C)	Wave 1 shorter than Wave 2	Wave 1 higher than Wave 2	Wave 1 has the same speed as Wave 2
(D)	Wave 1 shorter than Wave 2	Wave 1 higher than Wave 2	Wave 1 is slower than Wave 2

52. Rutherford's gold foil alpha particle scattering experiments showed that while most alpha particles fired at a gold foil sample passed straight through, about 1 in 10,000 were scattered backwards. Rutherford realized that this phenomenon could be accounted for by assuming that

(A) alpha particles must be ricocheting off the electrons.
(B) all of the positive charge and most of the mass of the atom is concentrated in a tiny kernel.
(C) alpha particles were annihilating the metal atoms.
(D) Thomson's plum pudding model was valid.

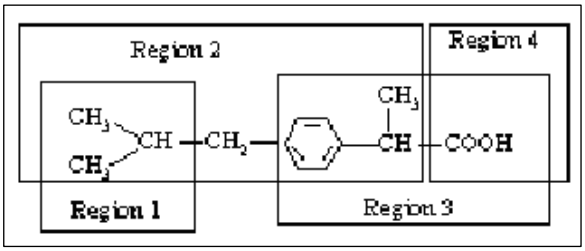
53. Which of the following signs should be prominently displayed in a chemistry laboratory?

(A) I only
(B) II only
(C) III only
(D) All should be displayed.



54. Which region of ibuprofen is most responsible for the fact that this drug dissolves well in nonpolar cell membranes and fatty tissues?

(A) Region 1 (B) Region 2
(C) Region 3 (D) Region 4



55. In the following equilibrium below, use the values in the table and calculate the value of K_c.

$$Ag_3PO_4(s) + 6\ NH_3(aq) \rightleftarrows 3\ Ag(NH_3)_2^+ + PO_4^{3-}(aq)$$

$Ag_3PO_4(s) \rightleftarrows 3\ Ag^+(aq) + PO_4^{3-}(aq)$	$K_c = 2.8 \times 10^{-18}$
$Ag(NH_3)_2^+ \rightleftarrows Ag^+(aq) + 2\ NH_3(aq)$	$K_c = 6.3 \times 10^{-8}$

(A) 1.5×10^{-11} (B) 8.9×10^{-5} (C) 1.1×10^{4} (D) 6.8×10^{10}

56. For the reaction: $2\ H_2O_2(aq) \rightarrow 2\ H_2O(aq) + O_2(g)$

How does the value of $\frac{\Delta[H_2O_2]}{\Delta t}$ compare with $\frac{\Delta[O_2]}{\Delta t}$?

(A) $\frac{\Delta[H_2O_2]}{\Delta t} = \frac{\Delta[O_2]}{\Delta t}$

(B) $-\frac{\Delta[H_2O_2]}{\Delta t} = \frac{\Delta[O_2]}{\Delta t}$

(C) $\frac{\Delta[H_2O_2]}{\Delta t} = 2\frac{\Delta[O_2]}{\Delta t}$

(D) $-\frac{\Delta[H_2O_2]}{\Delta t} = 2\frac{\Delta[O_2]}{\Delta t}$

Questions 57, 58, and 59 deal with aqueous solutions of hydrogen peroxide, H_2O_2.
(H_2O_2 = 34.0 g/mole, H_2O = 18.0 g/mole)

57. Commercial hydrogen peroxide has a concentration (%w/w) of 35% H_2O_2 in water and a density of 1.132 g/mL. What is the molarity of 35% H_2O_2?

(A) 9.09 M (B) 11.6 M (C) 15.8 M (D) 33.3 M

58. What is the mole fraction of H_2O_2 in a 35% solution?

(A) 0.222 (B) 0.285 (C) 0.504 (D) 0.654

59. How many mL of 35% H_2O_2 are required to make 500 mL of 2% H_2O_2? The density of the 2% solution is the same as water, 1.00 g/mL.

(A) 22.5 mL (B) 25.4 mL (C) 27.7 mL (D) 28.6 mL

60. What is the pH of a 0.010 M chloroacetic acid ($CH_2ClCOOH$) solution? $K_a = 1.41 \times 10^{-3}$

(A) 2.43 (B) 2.51 (C) 2.85 (D) 3.15

61. Which statement is **INCORRECT**?

(A) The second ionization energy is always larger than the first ionization energy.
(B) Elements with high ionization energies tend to have large atomic radii.
(C) First ionization is the minimum amount of energy required to remove the most loosely held electron from a gaseous atom.
(D) Elements with low ionization energies typically form ionic compounds with nonmetals by losing electrons.

62. Barium-142 has a half-life is 11 minutes. How long will it take for a 30.0 ppm sample of the Ba-142 in a particular sample to decompose to approximately 1 ppm?

(A) 33 minutes (B) 44 minutes (C) 55 minutes (D) 66 minutes

63. The true percentage of water in $CuSO_4 \cdot 5H_2O$ is 36.08%. A student gently heats 1.550 g of $CuSO_4 \cdot 5H_2O$ in a crucible to drive off the water and finds that the anhydrous sample weighs 1.007 g. The percent relative error is

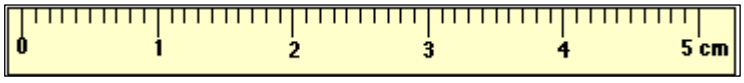
(A) 1.6% (B) 3.0% (C) 3.05% (D) 3.14%

64. What is the conjugate base of the acetate ion, $C_2H_3O_2^-$, in the following reaction?

$$HC_2H_3O_2 + NH_3 \rightleftarrows C_2H_3O_2^- + NH_4^+$$

(A) $HC_2H_3O_2$ (B) NH_3 (C) NH_4^+ (D) None of the above

65. Which set of measurements are all consistent with the metric ruler shown below?

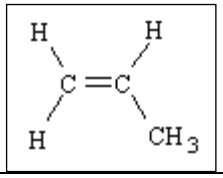


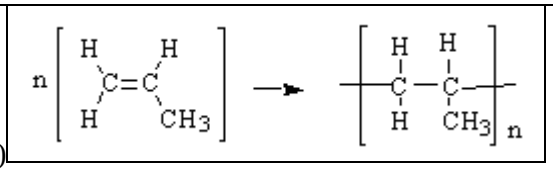
(A) 1.5 cm, 2.0 cm, 2.3 cm
(B) 4.50 cm, 1.500 cm, 3.45 cm
(C) 1.50 cm, 1.55 cm, 2.35 cm
(D) 2.4 cm, 3.4 cm, 4.75 cm

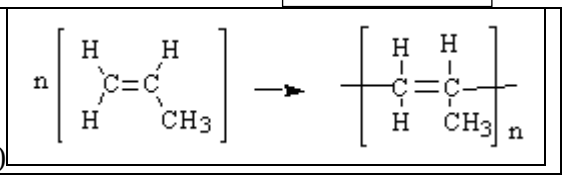
66. Which radioactive process is correctly matched to its effect on the neutron/proton (n/p) ratio?

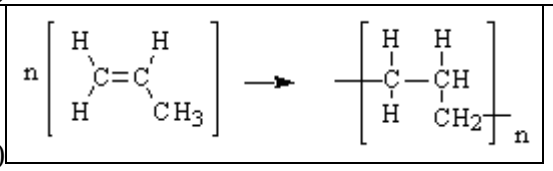
(A) positron emission: decreases the n/p ratio
(B) beta emission: increases the n/p ratio
(C) alpha emission; increases the n/p ratio or it stays the same
(D) electron capture: decreases the n/p ratio

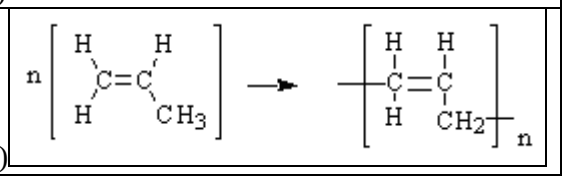
67. Polypropylene is one of the top six polymers. It is formed from the propylene monomer show to the right. Which choice shows the formation of the polymer?



(A) 

(B) 

(C) 

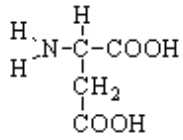
(D) 

68. Research has shown that L-ibuprofen is an effective pain reliever but D-ibuprofen is not at all effective. What generalization can be drawn from this information?
   (A) Only the L-isomer can be microencapsulated or used as an implant. This difference in packaging is responsible for the difference in the biochemical activity.
   (B) These two structural isomers behave exactly the same in biological systems, but only L-ibuprofen blocks the pain signal.
   (C) The difference in behavior illustrates the molecular specificity of a substrate for its binding site positrons.
   (D) Biochemical activity is related to the molecular weight of a drug.

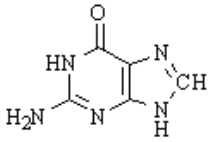
69. When 25.00 mL of 0.100 M $HC_2H_3O_2$ is titrated with 0.100 M NaOH, what is the pH of the solution when 24.90 mL of the base is added? $K_a = 1.8 \times 10^{-5}$

   (A) 4.7 (B) 6.9 (C) 7.1 (D) 8.7

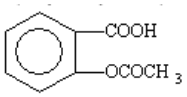
Questions 70-72 deal with the molecules below



I



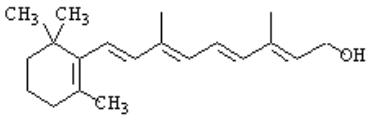
II



III

$[Co(NH_3)_4Cl_2]^+$

IV



V

70. The molecule(s) that can form geometric isomers

   (A) I only (B) V only (C) IV and V only (D) I and III only

71. The molecule that is a pain reliever

   (A) I (B) II (C) III (D) V

72. The molecule that is a vitamin

(A) I (B) II (C) III (D) V

73. The following reaction: $2\ HBr(g) \rightleftarrows H_2(g) + Br_2(g)$

The values of the equilibrium constant temperatures are:

$K_c = 1.3 \times 10^{-12}$	500 K
$K_c = 9.0 \times 10^{-18}$	300 K

What is the ΔH for this reaction in kJ/mol? ($R = 8.31 \times 10^{-3}$ kJ/mol)

(A) -67.8 kJ/mol (B) 16.5 kJ/mol (C) 74.0 kJ/mol (D) 97.2 kJ/mol

74. How much energy is lost when a <u>mole</u> of cobalt-60 undergoes beta decay as shown below

$$^{60}_{27}\text{Co} \rightarrow {}^{0}_{-1}\text{e} + {}^{60}_{28}\text{Ni}$$

The masses of $^{60}_{27}\text{Co}$ and $^{60}_{28}\text{Ni}$ are 59.9338 amu and 59.9308 amu respectively. $c = 3.0 \times 10^8$ m/s, Avogadro's number = 6.02×10^{23}

(A) -2.7×10^{11} J
(B) -2.7×10^{14} J
(C) -1.6×10^{38} J
(D) -1.8×10^{43} J

75. Hydrates are ionic compounds that have a definite amount of water as part of their structure, for example, $CuSO_4 \cdot 5H_2O$. To determine an experimental value, a crucible and lid are cleaned, heated to dryness, cooled, and weighed. A hydrate is added to the crucible and weighed. When the hydrate is heated, the "water of hydration" is lost as water vapor. The remaining solid, the anhydrous salt, is weighed in the crucible and the percent water of hydration in the sample is calculated. For $CuSO_4 \cdot 5H_2O$ the dehydration equation is

$$CuSO_4 \cdot 5H_2O(s) \xrightarrow{heat} CuSO_4(s) + 5H_2O(g)$$

Which of the possible sources of experimental error listed below will result in **<u>higher</u>** experimental percent of water of hydration than the theoretical value?

I. Not heating the crucible to dryness prior to adding the hydrated salt.
II. Using too hot a flame, resulting in decomposition of the hydrate
III. Using too cool a flame to drive off all the water of hydration.
IV. Not cooling the crucible after driving off the water of hydration.
V. Weighing too long after the dehydration is completed

(A) I, II, IV (B) III, V (C) IV, V (D) II, IV

76. What is a MSDS?

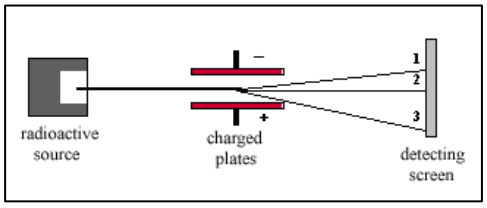
(A) Information on hazardous materials, substances, and wastes.
(B) An indicator used in acid-base titrations.
(C) A scientific instrument for analyzing sugars.
(D) A hazardous waste dangerous to the environment.

77. Which of the following procedures should be followed in the laboratory?

(A) Never return unused liquids to the reagent bottle. Place them in a container as designated by your teacher for proper disposal or, if so instructed, flush them down the laboratory sink using lots of water.
(B) When heating liquids in test tubes, always point the open end of the test tube away from yourself and other people. When heating liquids in beakers, stir the liquid while carefully heating to avoid bumping.
(C) Obtain liquids in a clean dry beaker---not a test tube or graduated cylinder. Do not put pipettes or medicine droppers into reagent bottles. Do not take reagent bottles to your desk.
(D) All are good procedures to follow.

78. The figure below shows a naturally radioactive source emitting an alpha particle, a beta particle, and a gamma ray. Which number identifies which type of emission?

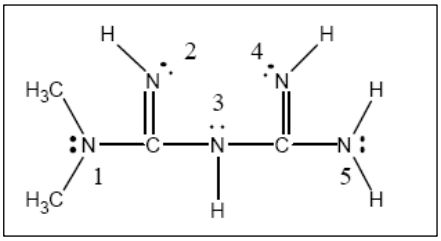
(A) 1 = gamma, 2 = beta, 3 = alpha
(B) 1 = beta, 2 = gamma, 3 = alpha
(C) 1 = beta, 2 = alpha, 3 = gamma
(D) 1 = alpha, 2 = gamma, 3 = beta



79. Acid rain has harmful to many things. Which **incorrectly** gives the effect that acid rain has on them?

(A) marble and granite; solubility of carbonate salts
(B) steel; increased oxidation
(C) the health of a human's lungs; allergy to gaseous SO_2
(D) trees; growth reduction and leaf loss

80. Metformin is the chemical name for a prescription drug sold as a "glucophage," a pill that lowers blood sugar. From Lewis structure of metformin, the geometry and formal charge around the nitrogen atom in the center of the molecule, e.g., N(3) is



(A) trigonal pyramidal, N(3) = 0
(B) trigonal pyramidal, N(3) = +1
(C) trigonal planar, N(3) = 0
(D) trigonal planar, N(3) = +1

81. Select all of the following relationships when graphed give a straight line for an ideal gas.

I. Average kinetic energy versus T at constant mass
II. P versus 1/V at constant temperature and constant mass
III. V versus 1/T at constant pressure and constant mass

(A) I (B) III (C) I and II (D) I, II, and III.

82. With aqueous solutions of HCl, NaOH, HF and NaF, the number of pairs that can be used to make a buffer is

(A) 1 (B) 2 (C) 3 (D) 4

83. A 0.3600 g sample of a hydrated barium halide, $BaX_2 \cdot 2H_2O$, where X is the halogen, was dissolved in water and precipitated as $BaSO_4$. The precipitate was filtered, washed and dried. Mass of precipitate obtained was 0.2533 g. Find the identity of X. ($BaSO_4$ = 233.4 g/mole, Ba = 137.3 g/mole)

(A) F (B) Cl (C) Br (D) I

84. In the reactions listed below, give all of the reactions that actually occur.

.

I $Ag + H_2SO_4 \rightarrow Ag_2SO_4 + H_2$
II $2\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$
III $2\ AlBr_3 + 3\ Cl_2 \rightarrow 2\ AlCl_3 + 3\ Br_2$
IV $Ca(C_2H_3O_2)_2 + Na_2CO_3 \rightarrow CaCO_3 + 2\ NaC_2H_3O_2$

(A) I, III (B) II, IV (C) II, III (D) II, III, IV

85. Which the following compounds/ions has the shortest CO bond length?

(A) CH_3OH (B) H_2CO (C) CO_3^{2-} (D) All CO bonds have the same length.

86. A chemist is examining the kinetics of a reaction where A→ products and obtained the data given in the table.
A plot of ln[A] vs. time does **NOT** give a straight line.
A plot of 1/[A] vs. time **DOES** give a straight line.
The concentration of A at 30 s is

time	Concentration of A
0	4.5 M
15 s	0.15 M

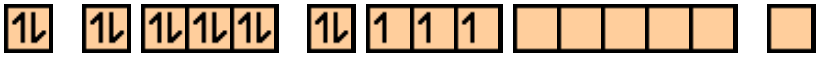
(A) 0.11 M (B) 0.08 M (C) 0.04 M (D) 0.03 M

87. X grams of water at 25.0°C are added to 20.0 g of ice at –10.0°C. The ice melts and the final temperature of the mixture is 10.0°C. The specific heat of water is 4.184 J/ g •K. The specific heat of ice is 2.092 J/ g •K. The molar enthalpy of fusion of ice is 6.008×10^3 J/mol.

(A) 45.4 g of water (B) 67.8 g of water (C) 89.3 g of water (D) 126 g of water

88. The average carbon monoxide, CO (28 g/mole), concentration in Dayton, Ohio in 2000 was 3.4 ppm. The number of CO molecules in 1.0 L of air at 27ºC and 1 atm pressure is, (Assume that air and CO have the same molar mass.)
(A) 3.4×10^{-6} (B) 1.4×10^{-7} (C) 8.3×10^{16} (d) 2.1×10^{18}

89. The diagram below shows the electronic configuration of an element using the electrons in boxes notation.



What is its chemical symbol?

(A) V (B) Al (C) As (D) P

90. Calculate $E°$ for this redox reaction (F =96500 C/mole)

$$2\ KMnO_4 + 3\ K_2C_2O_4 + 4\ H_2O \rightarrow 2\ MnO_2 + 6\ CO_2 + 8\ KOH; \quad \Delta G° = -625.3\ kJ$$

(A) $E°$ = 1.08 V (B) E^o = 2.16 V (C) $E°$ = 3.24 V (D) $E°$ = 6.48 V

91. Identify the **INCORRECT** statement below concerning the formation of solutions.
    (A) The large crystal lattice energy of ionic solids is generally favorable to their solution formation.
    (B) The entropy change upon mixing generally is a favorable factor for the formation of a solution.
    (C) An exothermic heat of solution would favor the formation of a solution relative to an endothermic one.
    (D) The exothermic hydration of ions in water is generally a favorable factor to solution formation.

92. What is the $[NH_4^+]$ concentration required to prevent precipitation of $Co(OH)_2$ from a solution that is 0.10 M $CoCl_2$ and 0.50 M NH_3? K_{sp} of $Co(OH)_2$ is 2.5×10^{-10} and K_b of $NH_3 = 1.8 \times 10^{-5}$

    (A) 0.18 M (B) 0.36 M (C) 0.44 M (D) 1.4 M

93. Which of the following are necessary before beginning your Lab activity?

    (A) Make sure you have read and understand all the directions carefully.
    (B) Prepare your lab notebook for data collection.
    (C) Ask your teacher for permission to start the lab.
    (D) All are necessary.

94. A 0.25 mole sample of solid sodium is completely combusted in pure oxygen in a calorimeter containing 200.0 g of water at 25°C, according to the following reaction:

    $4Na(s) + O_2(g) \rightarrow 2\ Na_2O(s) \quad \Delta H = -832$ kJ

    Assuming excess oxygen, and no heat loss, and the specific heat of the final solution is 4.18 J/g·°C, The temperature of the calorimeter water after the explosion is:

    (A) 26ºC (B) 36 ºC (C) 67ºC (D) 87ºC

95. When the following reaction was studied.

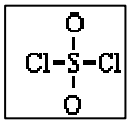
    $BrO_3^-(aq) + 5\ Br^-(aq) + 8\ H^+(aq) \rightarrow 3\ Br_2(l) + H_2O(l)$

    The following data were obtained. Based on these data, the rate equation is:

	Initial Concentration, M			Initial Rate, M/s
	$[BrO_3^-]$	$[Br^-]$	$[H^+]$	
Exp.1	0.10	0.10	0.10	8.0×10^{-4}
Exp.2	0.20	0.10	0.10	1.6×10^{-3}
Exp.3	0.10	0.20	0.10	1.6×10^{-3}
Exp.4	0.10	0.10	0.20	3.2×10^{-3}

    (A) Rate = $k[BrO_3^-][Br^-]^5[H^+]^8$
    (B) Rate = $k[BrO_3^-]^2[Br^-]^2[H^+]^4$
    (C) Rate = $k[BrO_3^-][Br^-][H^+]$
    (D) Rate= $k[BrO_3^-][Br^-][H^+]^2$

96. The VSEPR molecular structure and hybridization around the central S in sulfuryl chloride, SO_2Cl_2 is



    (A) tetrahedral, sp^3
    (B) see-saw, dsp^3
    (C) square planar, d^2sp^3
    (D) square planar, dsp^3

97. The percent "available chlorine" refers to the strength of a bleaching agent and is the ratio of the mass of Cl_2 to the 100. grams of the bleach mixture, even if Cl_2 is not actually present in the bleach. If sodium hypochlorite is the bleaching agent in a bleach solution, the percent "available chlorine" is determined by how sodium hypochlorite can be produced from chlorine and NaOH.

$$Cl_2(aq) + 2\ NaOH(aq) \rightarrow NaClO(aq) + NaCl(aq) + H_2O(l)$$

Stop and Shop bleach lists sodium hypochlorite as its active ingredient as 6.0%, by mass. The percent "available chlorine" in Stop and Shop bleach is (NaOCl = 74.4 g/mole, Cl_2 = 70.9 g/mole)

(A) 2.9% (B) 5.7%. (C) 6.3% (D) 11%

98. A bleaching powder reacts with iodide ion according to the following equation:

$2H^+ + OCl^- + 2I^- \rightarrow Cl^- + I_2 + H_2O$
$I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-$

A 0.6000 g sample of bleaching powder requires 35.24 mL of 0.1084 N $Na_2S_2O_3$ to titrate the liberated iodine. The percentage of chlorine in the sample is

(A) 22.58% (B) 5.15% (C) 11.28% (D) 45.16%

99. In the following equilibrium

$$NH_4HS(s) \rightleftarrows NH_3(g) + H_2S(g).$$

A 4.65 g sample of solid NH_4HS (51.13 g/mole) is placed in an evacuated 3.0 L flask at 35°C and allowed to reach equilibrium. The total pressure in the flask is 0.82 atm. What is the value of K_p at this temperature?

(A) 0.17 (B) 0.41 (C) 0.45 (D) 0.90

100. The following rate constants were measured as a function of temperature for an ester hydrolysis reaction. Find the activation energy for the reaction. (R = 8.314 J/ mol•K)

(A) 5.7 kJ (B) 47.0 kJ (C) 56.5 kJ (D) 57.5 kJ

T(K)	k(L mol^{-1} s^{-1})
288	1.04×10^{-3}
318	6.64×10^{-3}