Name:_____

1 H 1.008																	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											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.08	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 72.59	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 183.9	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 226.0	89 Ac 227.0	104 Rf (261)	105 Ha (262)	106 Sg (263)	107 Ns (262)	108 Hs (266)	109 Mt (266)									

Lanthanides	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
Actinides	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.0	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

Potentially Useful Equations and Data

$$C_g = k_H P_g,$$
$$P_{Solvent} = X_S P^\circ_{Solvent},$$
$$\Delta T_{Bp} = K_{Bp} m_{Solute}$$
$$\Delta T_{Fp} = K_{Fp} m_{Solute},$$
$$\Pi = MRT$$
$$A = kN,\ \Delta E = \Delta mc^2$$

Henry's Constants (at 25 °C)

Gas	K_H
N_2	8.42 x 10^{-7} M/mmHg
O_2	1.66 x 10^{-6} M/mmHg
CO_2	4.48 x 10^{-5} M/mmHg

$$pH = -log[H_3O^+]$$
$$pOH = -\log[OH^-]$$
$$pK_a = -\log[K_a]$$
$$pH = pK_a - \log\left[\frac{HA}{A^-}\right]$$

For $aA + bB \rightarrow cC + dD \ldots$

$$\text{Rate} = -\frac{1}{a}\frac{\Delta[A]}{\Delta t} = -\frac{1}{b}\frac{\Delta[B]}{\Delta t} = \frac{1}{c}\frac{\Delta[C]}{\Delta t} = \frac{1}{d}\frac{\Delta[D]}{\Delta t}$$
$$Forward\ Rate = k[A]^n[B]^m$$
$$\ln(a) + \ln(b) = \ln(ab),\ \ln(e^{ax}) = ax$$
$$\ln(a) - \ln(b) = \ln(a/b),\ e^{\ln(ax)} = ax$$
$$\ln(e^{ax}) = ax,\ e^{\ln(ax)} = ax$$
$$\frac{1}{[A]_f} = \frac{1}{[A]_o} + kt,$$
$$[A]_f = [A]_o - kt,$$
$$\ln[A]_f = \ln[A]_o - kt,$$
$$\frac{\ln 2}{k} = t_{1/2},\ k = Ae^{-E_a/RT}$$
$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

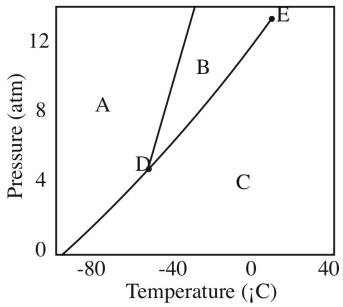
$$\Delta G^\circ = -nf\mathcal{E}^\circ$$
$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$
$$\Delta G^\circ = -RT\ln K$$
$$\Delta G = \Delta G^\circ + RT\ln Q$$

1 atm =760 mmHg
1 mL H_2O = 1 g H_2O
R=8.31451 J/Mol K
R=0.082057 L•atm/K•mol
c=2.99792458 x 10^8 m/sec
mass e^- = 5.485799x10^{-4}amu
mass p^+ = 1.00727646 amu
mass n = 1.00866492 amu
charge e^- = 1.6022 x 10^{-19} C
1 amu = 1 g/mol
1 J = 1 kg m^2 sec^{-2}
1 US$=70.0994 Syrian Pounds
K_w = 1 x 10^{-14}

F = 96,485.31 C/Mol
1 V = 1 J/C

NAME_____

For Questions 1 & 2 consider the phase diagram of CO_2 on the right.



1. In which region is CO_2 (g) the only species present?
(a) A (b) B (c) C
(d) D (e) E

2. Between which two regions does sublimation occur?
(a) A-B (b) B-C (c) A-C
(d) C-D (e) A-D

3. Which of the following is not a colligative property of a solution?
(a) freezing point depression (b) boiling point elevation (c) density
(d) vapor pressure reduction (e) osmotic pressure

4. An aqueous solution of sucrose freezes at -3.35 ºC. What is the molality of the solution? The freezing-point-depression constant of water is 1.86 ºC.
(a) 0.55 m (b) 1.80 m (c) 6.23 m (d) 0.38m (e) 1.20 m

5. Which liquid or solution will have the lowest freezing point?
(a) pure H_2O (b) 0.50 m glucose (c) 0.50 m sucrose
(d) 0.22 m CH_3OH (e) 0.50 m KF

For 6 and 7 consider the dissolution of O_2 (g) in water at 25°C, O_2 (g) $\rightleftharpoons$ O_2 (aq), $\Delta H > 0$

6. If the temperature is raised to 50 °C the concentration of O_2 (aq) will.
(a) increase (b) decrease (c) remain constant (d) =hν
(e) can't determine

7. If the external O_2 (g) pressure is raised the concentration of O_2 (aq) will,
(a) increase (b) decrease (c) remain constant (d) =hν
(e) can't determine

8. Consider the following aqueous solutions, A: 0.20 *m* sucrose, B: 0.15 *m* NaCl, & C: 0.05 *m* $CaCl_2$. Which inequality best describes the relative boiling points of these solutions?

(a) A<B<C (b) A<C<B (c) C<B<A (d) B<A<C
(e) C<A<B

NAME_____

For questions 9 – 11, consider the decomposition of hydrogen peroxide described by following reaction:

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

with the following thermodynamic values:

Compound	ΔH_f^o (kJ/mol)	ΔG_f^o (kJ/mol)	S^o (J/K-mol)
$H_2O_2(l)$	-187.8	-120.4	109.6
$H_2O(l)$	-285.8	-237.13	69.9
$O_2(g)$	0	0	205.1

9. Calculate the ΔH^o for the hydrogen peroxide reaction
   (a) 98 kJ/mol (b) 196 kJ/mol (c) -96 kJ/mol (d) -196 kJ/mol (e) none of these

10. Calculate the ΔS^o for the hydrogen peroxide reaction
   (a) 125.7 J/K·mol (b) -79.4 J/K·mol (c) 45.6 J/K·mol (d) -125.7 J/K·mol (e) none of these

11. Calculate the ΔG^o for the hydrogen peroxide reaction
   (a) 233.4 kJ/mol (b) 158.5 kJ/mol (c) -158.4 kJ/mol (d) -202.8 kJ/mol (e) none of these

12. For another reaction, ΔH^o = +56.8 kJ and ΔG^o = +45.0 kJ/mol. What is the ΔS^o of this reaction in J/K·mol (T = 25 °C)?
   (a) 39.6 J/K·mol (b) -39.6 J/K·mol (c) 472 J/K·mol
   (d) -472 J/K·mol (e) none of these

13. The second law states that a spontaneous chemical reaction will be accompanied by :
   (a) an increase in the entropy of the chemicals (ΔS^o of reaction > 0)
   (b) an increase in the enthalpy of the chemicals (ΔH^o of reaction > 0)
   (c) an increase in the free energy of the chemicals (ΔG^o of reaction > 0)
   (d) an increase in the entropy of the universe ($\Delta S_{total} > 0$)
   (e) none of these

14. The following reaction: A(*g*) + 2B(*s*) → C(*g*) + D(*g*), $\Delta H < 0$, will be spontaneous at:
   (a) Low T (b) High T (c) All T (d) No T (e) can't determine

15. For a first-order reaction, a graph of which quantities would give a straight line for reactant A?
   (a) [A] vs time (b) ln A vs time (c) $1/[A]$ vs time
   (d) $1/[A]$ vs temp (e) $[A]^2$ vs time

16. A first-order chemical reaction is observed to have a rate constant of 25.0/min. What is the half-life of the reaction?
   (a) 12.5 min (b) 17.3 min (c) 0.29 sec (d) 4.62×10^{-4} sec (e) 0.0277 min

NAME_____

17. The reaction mechanism for the decomposition of H_2O_2 is

$$H_2O_2 + I^- \rightarrow H_2O + IO^- \quad \text{slow}$$
$$H_2O_2 + IO^- \rightarrow H_2O + O_2 + I^- \quad \text{fast}$$

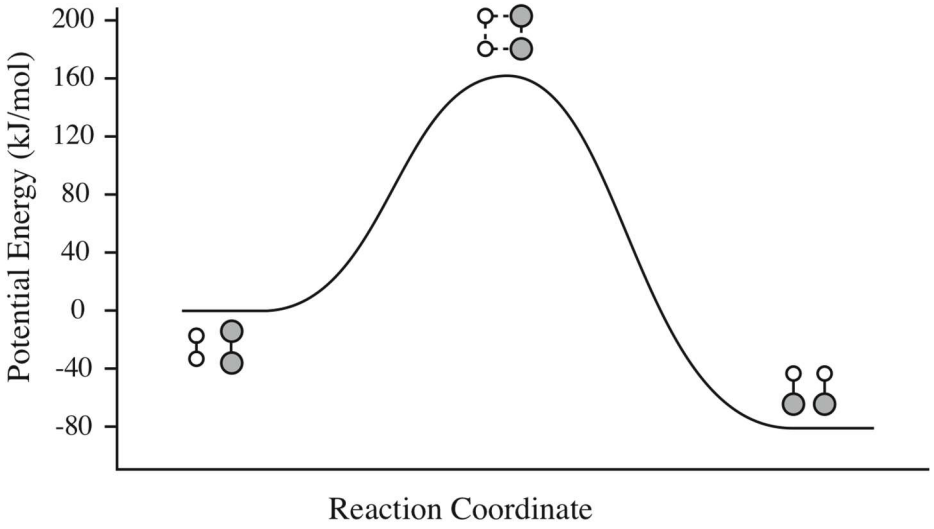
Which of the following statements is true?

(a) I^- is an intermediate.
(b) IO^- is an intermediate.
(c) The reaction is first order with respect to $[O_2]$.
(d) The reaction is zero-order with respect to $[I^-]$.
(e) The reaction is second-order with respect to $[H_2O_2]$.

For 18 consider the reaction,

$$H_2 + Br_2 \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} 2\ HBr$$

and the following energy profile obtained at 1000 K:



(18) Estimate the activation energy (E_a) for the forward reaction in kJ/mol.

(a) -80 (b) 0 (c) 80 (d) 160 (e) 240

(19) For the reaction 2A + B → C, with a rate law of: RATE=k[A]^2[B], calculate the rate constant, k (with units), when [A]=0.010 M and [B]=0.030 M and the initial rate is 2.1×10^{-2} mol/(L•sec)

(a) Not enough Information (b) $70\ L^2 / (mol^2 \bullet sec)$ (c) $70\ L / (mol \bullet sec)$

(d) $7.0x10^3\ L / (mol \bullet sec)$ (e) $7.0x10^3\ L^2 / mol^2 \bullet sec$

NAME_____

(20) Consider the following data for the reaction at 25 °C:

$$2NO\ (g) + O_2\ (g) \rightarrow 2NO_2\ (g)$$

Initial $[O_2]$ (mol / L)	Initial [NO] (mol / L)	Initial rate (mol / L·sec)
0.01	0.01	7.0×10^{-3}
0.01	0.03	2.1×10^{-2}
0.03	0.03	1.9×10^{-1}

The reaction order for NO and O_2 is ___ and ___, respectively.

(a) 0^{th} , 1^{st} (b) 1^{st}, 0^{th} (c) 1^{st}, 1^{st} (d) 1^{st}, 2^{nd} (e) 2^{nd}, 1^{st}

For the equilibrium (Questions 21 & 22): $6\ CO_{2\ (g)} + 6\ H_2O_{(l)} \rightleftharpoons C_6H_{12}O_{6\ (s)} + 6\ O_{2\ (g)}$

21. Which of the following is the correct equilibrium expression for the reaction.

a) $K_c = \dfrac{[C_6H_{12}O_6][O_2]^6}{[CO_2]^6[H_2O]^6}$ c) $K_c = [C_6H_{12}O_6][O_2]^6$ e) $K_c = \dfrac{[O_2]^6}{[CO_2]^6}$

b) $K_c = \dfrac{[C_6H_{12}O_6]}{[H_2O]^6}$ d) $K_c = \dfrac{[C_6H_{12}O_6][O_2]}{[CO_2][H_2O]}$

22. Increasing pressure would shift the equilibrium

(a) to the right. (b) to the left (c) would leave the equilibrium unchanged.

23. For the reaction $2\ COF_{2\ (g)} \rightleftharpoons CO_{2\ (g)} + CF_{4\ (g)}$, what is the equilibrium constant, K_C, if $[COF_2] = 0.035\ M$, $[CO_2] = 0.32\ M$, and $[CF_4] = 0.0075\ M$ at equilibrium at 1000 ºC?

(a) 8.4×10^{-6} (b) 0.034 (c) 0.068 (d) 2.0 (e) 49

24. The equilibrium constant, K_P, for the reaction $SO_2Cl_{2\ (g)} \rightleftharpoons SO_{2\ (g)} + Cl_{2\ (g)}$ is 3.0 at 173 ºC. If $P_{SO_2Cl_2} = 0.12$ atm, $P_{SO_2} = 47$ atm, and $P_{Cl_2} = 0.015$ atm, the reaction:

(a) will shift right. (b) will shift left. (c) is at equilibrium.

25. What is ΔG^o for the reaction in problem 24 at 173 ºC in kJ?

(a) 1.6 (b) 8.3 (c) 0.040 (d) 40 (e) 4.0

26. Which of the following would change the value of the equilibrium constant?

(a) change in pressure (b) changes in concentration (c) addition of a catalyst
(d) change in temperature (e) all of these

NAME_____

27. What is the pH of a 0.46 *M* nitrous acid, HNO_2, solution ($K_a = 4.5 \times 10^{-4}$)?

(a) 0.34 (b) 1.84 (c) 3.35 (d) 3.68 (e) 4.22

28. K_a for nitrous acid is 4.5×10^{-4}. What is K_b for its conjugate base?

(a) 2.2×10^{-11} (b) 2.22×10^{-7} (c) 2.22×10^{-4} (d) 2.22 (e) 2.2×10^{2}

29. Which of the following is the conjugate base to $H_2PO_4^-$?

(a) PO_4^{3-} (b) HPO_4^{2-} (c) $H_2PO_4^-$ (d) H_3PO_4

30. Which of the following bases is strongest?

(a) ammonia ($K_b = 1.8 \times 10^{-5}$) (b) aniline ($K_b = 4.3 \times 10^{-10}$)

(c) hydrazine ($K_b = 1.3 \times 10^{-6}$) (d) methylamine ($K_b = 4.4 \times 10^{-4}$)

(e) pyridine ($K_b = 1.7 \times 10^{-9}$)

31. In a titration, 25.0 mL of a weak, monoprotic acid is titrated with 17.2 mL 0.144 *M* sodium hydroxide solution to reach its equivalence point. What is the concentration of the weak acid?

(a) 0.00248 *M* (b) 0.0991 *M* (c) 0.144 *M* (d) 0.209 *M* (e) 2.48 *M*

32. What is the pH of a solution that is 0.25 *M* in hypochlorous acid ($K_a = 3.0 \times 10^{-8}$) and 0.35 *M* hypochlorite ion?

(a) 4.31 (b) 5.42 (c) 7.38 (d) 7.52 (e) 7.67

33. Combination of equal molar amounts of a weak acid and a strong base yields a solution that
(a) is acidic. (b) is basic. (c) is neutral
(d) You must have K_a of the acid to answer this question.

34. What is the solubility product constant, K_{sp}, for lead(II) fluoride, PbF_2, if a saturated solution contains $[Pb^{2+}] = 0.0021$ *M* and $[F^-] = 0.0042$?

(a) 2.1×10^{-3} (b) 1.8×10^{-5} (c) 8.8×10^{-6} (d) 1.5×10^{-7} (e) 3.7×10^{-8}

35. What is the molar solubility of nickel(II) hydroxide, $Ni(OH)_2$, if the pH of the solution is 10.00? ($K_{sp} = 6.0 \times 10^{-16}$)?

(a) 1.5×10^{-8} (b) 6.0×10^{-8} (c) 1.5×10^{-12} (d) 6.0×10^{-12}

36. A bidentate ligand is a Lewis _____ that can _____ two electron pairs.
(a) base, accept (b) base, donate (c) acid, accept
(d) acid, donate (e) structure, use

NAME_____

For questions 37 through 40 consider the complex $[Co(en)_2F_2]NO_3$.

37. Which of the following species is **not** in the coordination complex?
(a) Co (b) en (c) F (d) NO_3 (e) All in

38. What is the geometry around the central Co ion?
(a) Octahedral (b) Square Planar (c) Tetrahedral
(d) Square Planar or Tetrahedral (e) Trigonal Bilinear

39. How many 4d electrons are on central Co ion?
(a) 0 (b) 1 (c) 2 (d) 3 (e) 4

40. The number of unpaired electrons on Co in a low spin (spin-paired) complex would be
(a) 0 (b) 1 (c) 2 (d) 3 (e) 4

For questions 41 through 44 consider the reaction:

$MnO_4^-(aq) + Cl^-(aq) \text{ ---> } Mn^{2+}(aq) + Cl_2(aq)$ (acidic solution)

41. When the reaction is balanced, one finds that the reducing agent is:
(a) MnO_4^- (b) Cl^- (c) Mn^{2+} (d) Cl_2 (e) H_3O^+

42. The number of electrons (n) involved in the balanced reaction is:
(a) 5 (b) 6 (c) 8 (d) 10 (e) 12

43. The potential associated with this reaction is + 0.15 V. What is the value of ΔG^0_{Rxn} (kJ)?
(a) 14.5 (b) 145 (e) 72.5 (d) -145 (e) -14.5

44. What is the value of K_{eq} for this reaction at 298K ?
(a) 3.8×10^{-26} (b) 6×10^2 (c) 1.1 (d) 0.94 (e) 2.6×10^{25}

45. What is the oxidation half-reaction for the following REDOX reaction?

$2KBr(l) \rightarrow 2K(l) + Br_2(g)$

(a) $2\,Br^- \rightarrow Br_2 + 2e^-$ (b) $Br_2 + 2e^- \rightarrow 2Br^-$ (c) $2K^+ + 2e^- \rightarrow 2K$
(d) $2K \rightarrow 2K^+ + 2e^-$ (e) $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

46. When a uranium-238 nucleus (^{238}U) undergoes 2 alpha emissions and 2 beta emissions, the nucleus formed is
(a) ^{84}Po (b) ^{230}Th (c) ^{227}U (d) ^{230}Ra (e) ^{228}Pa

47. What is the name given to the amount of energy it would take to separate the nucleus into its individual nucleons?
(a) nuclear fission (b) nuclear fusion (c) electron capture
(d) binding energy (e) ionization energy
.

48. How many nucleons are present in one $^{16}O^{2-}$ anion?
(a) 16 (b) 8 (c) 10 (d) 26 (e) none of these

NAME_____

49. Atoms of the same element with different mass numbers are called
(a) isobars (b) isotopes (c) allotropes (d) isomers (e) nucleons

50. The half-life of ^{90}Sr is 28 years. How long will it take for a sample of ^{90}Sr to be 85% decomposed?
(a) 29 years (b) 77 years (c) 88 years (d) 94 years (e) 110 years.