CHEMISTRY 104
Hour Exam II
Summer 2025

Name _____

Multiple Choice Questions

GRADING:

MC_____ (75)

26. _____ (9)

27. _____ (10)

28. _____ (11)

29. _____ (12)

30. _____ (9)

31. _____ (12)

32. _____ (11)

Total _____ **149**

For best results please don't leave blanks on the objective or written-out problems.
Please show all steps or logic on the written problems so partial credit can be awarded.

MULTIPLE CHOICE – three (3) points each

1. Which of the following statements (a-d) is **true**?

   a) Good reducing agents have large, positive reduction potentials.
   b) The overall reaction in a galvanic cell has a positive free energy change ($\Delta G > 0$).
   c) The overall reaction in an electrolytic cell has a positive cell potential ($E_{cell} > 0$).
   d) In a galvanic cell, the anode is where reduction occurs.
   e) None of the above statements (a-d) is true.

Use the following table of standard reduction potentials to answer the next two questions.

	E° (volts)
$Ag^{2+} + e^- \rightarrow Ag^+$	+1.99
$Cl_2 + 2e^- \rightarrow 2\ Cl^-$	+1.36
$Ag^+ + 2e^- \rightarrow Ag$	+0.80
$Cu^{2+} + 2e^- \rightarrow Cu$	+0.34
$Pb^{2+} + 2e^- \rightarrow Pb$	−0.13
$Ni^{2+} + 2e^- \rightarrow Ni$	−0.23
$Fe^{2+} + 2e^- \rightarrow Fe$	−0.44
$Mg^{2+} + 2e^- \rightarrow Mg$	−2.37

2. The ionic compound $AgCl_2$ is unstable. Which of the following best explains why $AgCl_2$ is unstable?

   a) Ag^{2+} will oxidize Cl^- making $AgCl_2$ unstable.
   b) Ag^{2+} will oxidize Cl_2 making $AgCl_2$ unstable.
   c) Ag^+ will oxidize Cl_2 making $AgCl_2$ unstable.
   d) Ag^+ will oxidize Cl^- making $AgCl_2$ unstable.

3. Which of the following can act as a sacrificial metal to protect iron from corrosion?

   a) Ni b) Ag c) Pb d) Cu e) Mg

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4. Consider the concentration cell: $Al \mid Al^{3+}\ (0.10\ M) \parallel Al^{3+}\ (1.5\ M) \mid Al$

   What effect would decreasing the $[Al^{3+}]$ at the cathode have on E_{cell}?

   a) No effect.
   b) E_{cell} would decrease.
   c) E_{cell} would increase.

5. A galvanic cell has a K value equal to 1.00. The cell reaction:

a) has a negative $\Delta G°$ value.
b) has $\Delta G° = 0$.
c) has a positive E^{o}_{cell} value.
d) has a negative E^{o}_{cell} value.
e) None of these answers (a-d) are true.

6. Given:

	E° (V)
$O_2 + 4\ H^+ + 4e^- \rightarrow\ 2\ H_2O$	+0.82
$I_2 + 2e^- \rightarrow 2\ I^-$	+0.54
$2\ H_2O\ + 2e^- \rightarrow H_2 + 2\ OH^-$	−0.41
$Cr^{3+} + 3e^- \rightarrow Cr$	−0.73

Consider the electrolysis of an aqueous solution of chromium iodide (CrI_3). Using the potentials above, which of the following statements describes what should be observed? Assume no overvoltage and assume standard conditions.

a) I^- will be produced at one electrode and H_2O will be produced at the other electrode.
b) I_2 will be produced at one electrode and Cr will be produced at the other electrode.
c) I_2 will be produced at one electrode and H_2 and OH^- will be produced at the other electrode.
d) O_2 and H^+ will be produced at one electrode Cr will be produced at the other electrode.
e) O_2 and H^+ will be produced at one electrode and H_2 and OH^- will be produced at the other electrode.

7. Which of the following statements is **false**?

a) Driving on roads which have been salted can increase the severity of corrosion.
b) Protective oxides can prevent corrosion by eliminating contact of the metal with oxygen and moisture.
c) Corrosion involves the oxidation of iron.
d) Corrosion is an example of an electrolytic process.
e) In general, cars rust more easily in the humid Midwest than in the arid (dry) southwest.

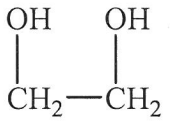
8. Consider a galvanic cell based on the following half-reactions:

	E° (V)
$Tl^+ + e^- \rightarrow Tl$	−0.34
$Au^{3+} + 3e^- \rightarrow Au$	1.50

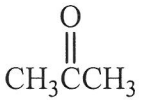
Calculate the cell potential at 25°C when $[Au^{3+}] = 1.0 \times 10^{-2}$ *M* and $[Tl^+] = 1.0 \times 10^{-4}$ *M*.

a) 2.04 V b) 1.84 V c) 1.64 V d) 0.96 V e) 1.36 V

9. Arrange the following substances in order of **increasing** vapor pressure at 25°C (from lowest to highest).

I. 

II. NaCl III. $CH_3CH_2CH_2OH$

IV. $CH_3CH_2CH_3$ V. 

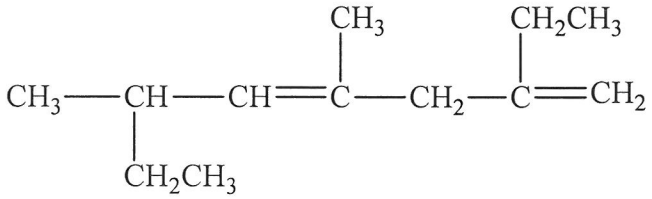
a) II < IV < V < III < I b) IV < V< III < I < II c) IV < III < I < V < II

d) II < I < III < V < IV e) IV < V < III < II < I

10. Which of the following statements about alkanes and cycloalkanes is **false**?

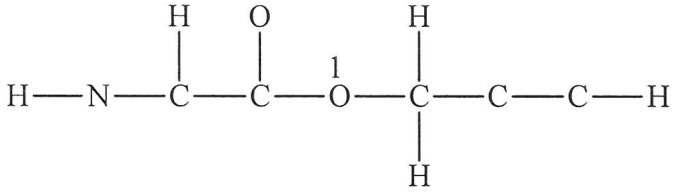
a) Cyclobutane exhibits ring strain since the observed bond angles are smaller than the preferred 109°.
b) Cycloalkanes are structural isomers of alkanes.
c) All carbons in alkanes are sp^3 hybridized.
d) Cycloalkanes can exhibit cis/trans isomerism.
e) Alkanes can rotate about every bond.

11. What is the IUPAC name for the following compound? (ignore cis/trans isomers)



a) 2-ethyl-4,6-dimethyl-1,4-octadiene
b) 2,6-diethyl-4-methyl-1,4-heptadiene
c) 7-ethyl-3,5-dimethyl-4,7-octadiene
d) 2,6-diethyl-4-methyl-3,6-heptadiene
e) 3,5,7-trimethyl-4-nonene

Complete the Lewis structure for the following organic molecule, then answer the next four questions.



12. How many π bonds does this molecule have?

a) 0 b) 1 c) 2 d) 3 e) 4

13. What is the bond angle about the oxygen atom labeled 1?

a) 60° b) 90° c) 109° d) 120° e) 180°

14. How many nitrogen and carbon atoms are sp^2 hybridized?

a) 1 b) 2 c) 3 d) 4

e) 5 (Five nitrogen and carbon atoms in this molecule exhibit sp^2 hybridization.)

15. How many bonds in the molecule are formed from overlap of a sp^3 hybrid orbital from one atom with a sp^3 hybrid orbital from another atom?

a) 0 b) 1 c) 2 d) 3 e) 4

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16. Which of the following organic compounds will decolorize a bromine solution?

a) benzene
b) 2-methylbutane
c) cycloheptane
d) trans-4-methyl-2-pentene
e) toluene

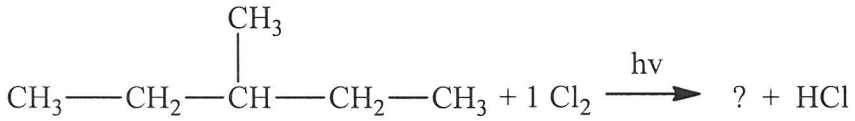
17. In class, the absent-minded professor carelessly named an organic compound, 2-3-dibromo-2,3-diisopropylbutane. An ever alert student pointed out, that although you could draw the correct structure from the professor's name, the name was not the correct IUPAC name. What is the correct IUPAC name for this compound?

a) 2,3-dibromo-1,1,2,3,4,4-hexamethylbutane
b) 3,4-dibromo-2,3-dimethyl-4-isopropylpentane
c) 3,4-dibromo-2-methyl-5-isopropylhexane
d) 3,4-dibromo-2,3,4,5-tetramethylhexane
e) 2,3-dibromo-5-methyl-2-isopropylpentane

18. Consider the combustion reaction of toluene. How many molecules of O_2 are required to react with each molecule of toluene?

a) 2.5 b) 5 c) 7.5 d) 8 e) 9

19. How many different <u>mono</u>chlorination products can be produced for the reaction shown below?



a) 2 b) 3 c) 4 d) 5 e) 6

20. Bromochloropropene (C_3H_4BrCl) exhibits structural, geometric and optical isomerism. How many of the eight noncyclic structural isomers for bromochloropropene are optically active? **Note:** ignore cyclic structures.

a) 1 b) 2 c) 3 d) 4 e) 5

21. Which answer has the correct fill in the blanks to make the following statement correct?

Ethane molecules interact by __I__ , whereas, methanol (CH_3OH) molecules interact mainly by __II__. London dispersion forces are __III__ than hydrogen bonding interactions in molecules of similar size. This explains why the boiling point of methanol (molar mass = 32 g/mol) is __IV__ the boiling point of ethane (molar mass = 30 g/mol).

a) I – London dispersion forces, II – ionic interactions, III – weaker, IV – higher than

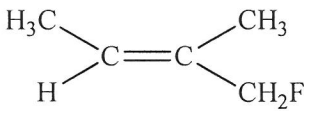
b) I – London dispersion forces, II – hydrogen bonding, III – weaker, IV – higher than

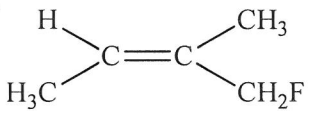
c) I – London dispersion forces, II – hydrogen bonding, III – stronger, IV – less than

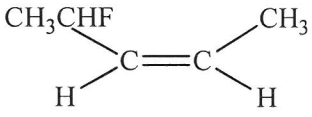
d) I – London dispersion forces, II – dipole-dipole, III – stronger, IV – less than

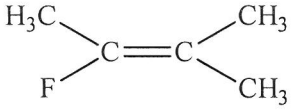
e) I – London dispersion forces, II – dipole-dipole, III – weaker, IV –less than

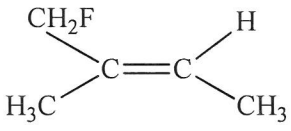
22. Consider the following compounds:

I. 

II. 

III. 

IV. 

V. 

Which of the following statements is **false**?

a) I and IV are structural isomers of each other.

b) II is a cis isomer.

c) I and III are structural isomers of each other.

d) I and II are geometrical isomers of each other.

e) I and V are structural isomers of each other.

23. Which of the following statements (a-d) is **false**?

a) Benzene based compounds must have some carbons that are sp hybridized.

b) The π bonds in alkenes, alkynes and benzene are formed from overlap of unhybridized p atomic orbitals.

c) Benzene based compounds are, in general, more stable than alkenes due to the delocalized π electrons found in benzene and its derivatives.

d) Alkenes, alkynes and benzene all have at least one bond that does not rotate.

e) None of the above statements (a-d) are false.

24. Which of the following diatomic molecules/ions is **least** likely to form?

a) Be_2 b) H_2 c) He_2^+ d) H_2^- e) Li_2

25. Which of the following statements is **false** regarding molecular orbital theory?

a) Bonding molecular orbitals are lower in energy than the atomic orbitals used to form them.

b) Diatomic molecules/ions having an odd number of electrons must be paramagnetic.

c) Antibonding molecular orbitals in diatomic molecules/ions have electron density mainly outside of the space between the two nuclei.

d) Electrons never occupy antibonding molecular orbitals.

e) The number of molecular orbitals formed is equal to the number of atomic orbitals used to construct them.

USEFUL CONSTANTS AND RELATIONS:

$N = 6.022 \times 10^{23}$; $PV = nRT$

$R = 8.3145\ J/mol \cdot K = 0.08206\ \frac{L \cdot atm}{mol \cdot K}$

$\Delta G = \Delta G° + RT \ln Q$; $\Delta G = w_{max}$

$K = °C + 273$

$F = 96{,}485\ Coul/mol\ e^-$

$Volt = J/Coul$

$E = E° - \frac{RT}{nF} \ln Q$

$E = E° - \frac{0.0591}{n} \log Q$ (at 25°C)

$\Delta G°_{rxn} = \Sigma \Delta G°_{f,\ products} - \Sigma \Delta G°_{f,\ reactants}$

$\Delta S_{univ} = \frac{-\Delta G}{T}$

$\Delta S_{surr} = \frac{-\Delta H}{T}$

$\Delta G = -nFE$

$\Delta G° = -nFE°$

$\Delta G° = -RT \ln K$

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

$\Delta G° = \Delta H° - T\Delta S°$

$E° = \frac{0.0591}{n} \log K$ (at 25°C)

$Amp = Coul/sec$

$k = A\ e^{-E_a/RT}$

$\%\ dissociation = \frac{amount\ dissociated}{initial\ concentration} \times 100$

$K_w = K_a \cdot K_b = [H^+][OH^-]$

$K_w = 1.0 \times 10^{-14}$ (at 25°C)

$pH + pOH = 14.00$

$pK_a + pK_b = 14.00$

$pH = -\log[H^+]$, $[H^+] = 10^{-pH}$

$pK_a = -\log K_a$

$pH = pK_a + \log \frac{[base]}{[acid]}$

Acid	K_a
HF	7.2×10^{-4}
$HC_2H_3O_2$	1.8×10^{-5}
HCN	6.2×10^{-10}

Base	K_b
NH_3	1.8×10^{-5}
H_2NNH_2	3.0×10^{-6}

$pH = \frac{pK_{a_1} + pK_{a_2}}{2}$

Zero order reaction:

$[A] - [A]_0 = -kt$

$t_{1/2} = \frac{[A]_0}{2k}$

First order reaction:

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

$\ln\left(\frac{[A]}{[A]_0}\right) = -kt$

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

Second order reaction:

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

$t_{1/2} = \frac{1}{k[A]_0}$

PERIODIC TABLE OF THE ELEMENTS

1A	2A											3A	4A	5A	6A	7A	8A
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 32.07	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 65.38	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	89 Ac‡ (227)	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn						

atomic number → 26 Fe 55.85 ← atomic mass

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)	92 U 238.0	93 Np (237)	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)