CHEMISTRY 104
Hour Exam II
Summer 2023

Name _____

Net ID _____

Multiple Choice Questions

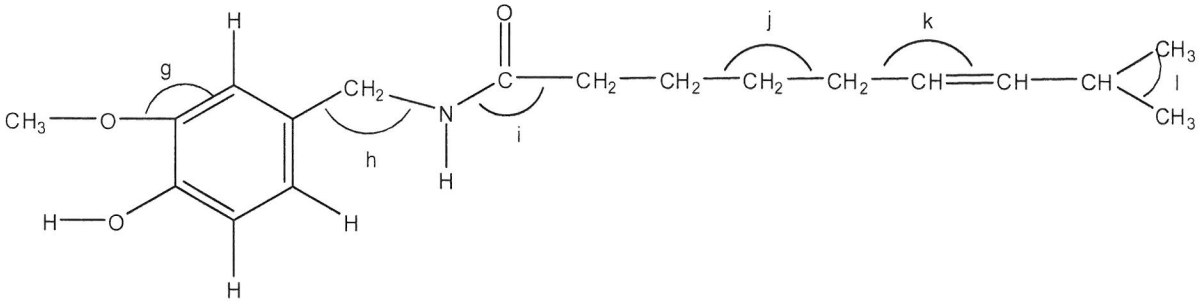
GRADING:

TF _____	(10)
MC_____	(69)
34. _____	(12)
35. _____	(6)
36. _____	(10)
37. _____	(10)
38. _____	(9)
39. _____	(6)
40. _____	(12)
41. _____	(6)
Total _____	**150**

Please show all steps or logic on the free response questions so partial credit can be awarded.

Answer the following **ten** questions (1-10) true (A) or false (B) **(1 point each).**

Capsaicin is the active compound in chili peppers. A partial Lewis structure for capsaicin is:



Complete the Lewis structure and answer the next **six** questions.

1. Of all the indicated bond angles (g-1), bond angle j is the largest.

2. There are more atoms with sp^2 hybridization than atoms with sp^3 hybridization.

3. The bond angles marked g, i and k are all approximately 120°.

4. The nitrogen atom is sp^2 hybridized.

5. There are 4 lone pairs of electrons in the completed Lewis structure.

6. The π bonds in capsaicin are all formed from overlap of unhybridized p atomic orbitals.

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7. CH_2O has a lower vapor pressure than C_2H_6 at 25°C.

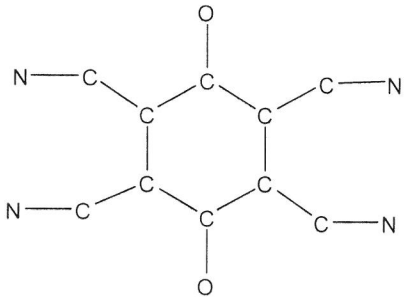
8. Batteries are example of electrolytic cells at equilibrium.

9. Alkynes can exhibit cis/trans isomerism.

10. The oxidation state of carbon in C_2H_5OH is −2.

MULTIPLE CHOICE (3 points each)

11. The skeleton structure of TCNQ, $C_{10}N_4O_2$, is given below. Complete the Lewis structure and answer the next question.



How many π bonds are in the completed Lewis structure?

a) 6 b) 8 c) 10 d) 12 e) 13

12. How many of the following compounds have free rotation about every bond in the molecule?

I. cyclopropane II. ethane III. ethene

IV. ethyne V. benzene

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

e) 5; All have free rotation about every bond.

13. In class, the TA named a molecule 2-ethyl-4-tert-butylpentane. An alert student pointed out that although the correct structure could be drawn, the name did not follow IUPAC rules. What is the correct IUPAC name for the molecule?

a) 5-methyl-2-tert-butylhexane

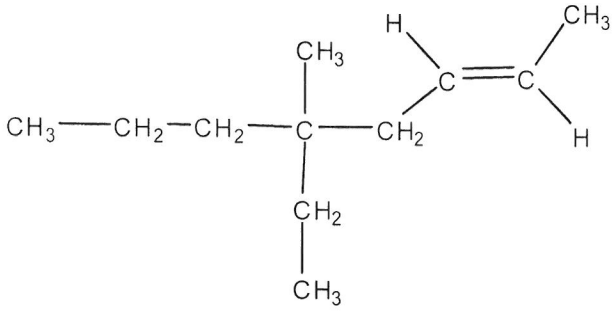
b) 2-ethyl-4,5,5-trimethylhexane

c) 3,5,6,6-tetramethylheptane

d) 2,2,3,5-tetramethylheptane

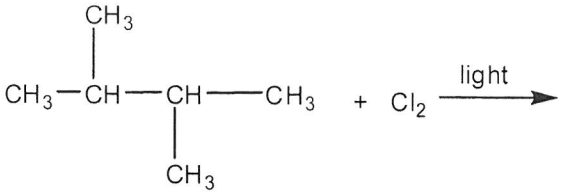
e) 3-methyl-4-tert-butylhexane

14. Name the following compound:



a) trans-5-ethyl-5-methyl-2-octene
b) trans-4 -ethyl-1,4-dimethyl-1-heptene
c) cis-3-methyl-3-propyl-6-hexene
d) trans-4-ethyl-4-methyl-6-octene

15. How many different **mono**chlorination products are formed in the reaction shown below?



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

16. How many of the following four types of hydrocarbons undergo addition reactions easily?

I. alkanes II. alkenes III. alkynes IV. aromatics

a) 0; None b) 1 c) 2 d) 3

e) 4; All easily undergo addition reactions.

17. Which of the following statements about cyclohexane is **false**?

a) Its molecular formula is C_6H_{12}.

b) The chair conformation is more stable than the boat conformation.

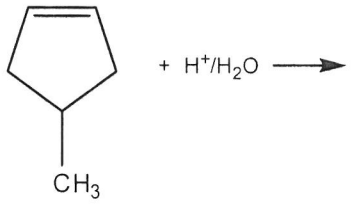
c) It is a planar molecule.

d) All bond angles are about 109°.

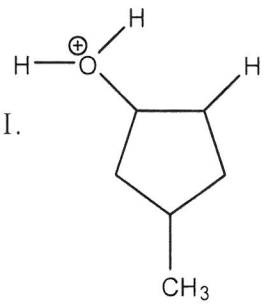
e) It is a structural isomer of 2-hexene.

18. Choose the correct order of reactants, intermediates and products for the acid catalyzed hydration of the following alkene.

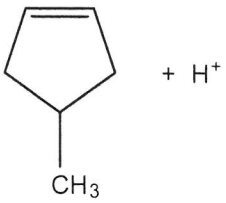
	first			**last**
a)	II,	III,	IV,	I
b)	II,	I,	IV,	III
c)	II,	IV,	III,	I
d)	III,	I,	IV,	II
e)	II,	IV,	I,	III



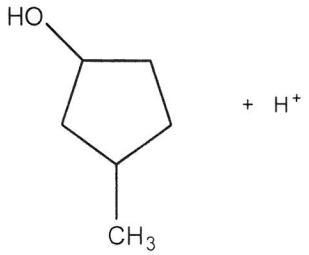
I.



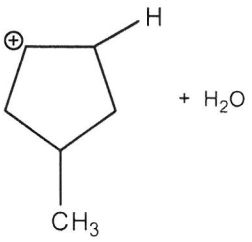
II.



III.



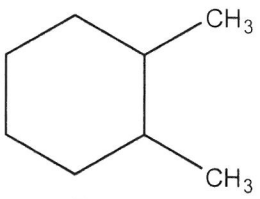
IV.



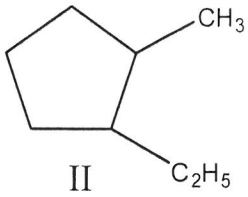
For the next two questions, refer to the compounds in Question 19.

19. Which of the following **compounds** (I-VI) exhibit cis-trans isomerism?

Pair X:

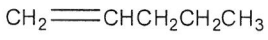


I

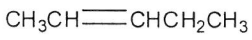


II

Pair Y:

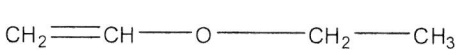


III

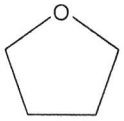


IV

Pair Z:



V



VI

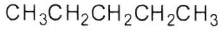
a) I, II, III, IV b) I, II, IV c) all of them d) III, IV, V e) II and IV only

20. In which of the **pairs** (X, Y, and Z) is/are the compounds structural isomers of each other?

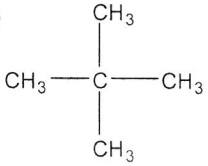
a) pair Y only b) pairs X and Y c) pairs Y and Z
d) pairs X and Z e) pairs X, Y and Z

21. Which of the following compounds will have the lowest boiling point?

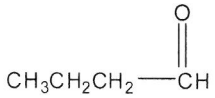
a)



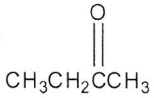
b)



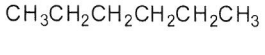
c)



d)



e)



22. Consider the MO diagrams for B_2, N_2, O_2, and F_2. How many of these four diatomic compounds are expected to be paramagnetic?

a) 0 (none) b) 1 c) 2 d) 3 e) 4 (All of them.)

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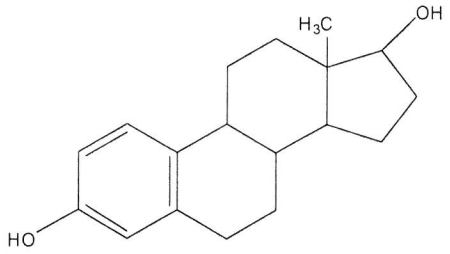
23. Estradiol is a female hormone with the following structure. How many carbon and oxygen atoms in estradiol are sp^3 hybridized?



a) 6
b) 8
c) 10
d) 14
e) 18

24. How many chiral carbons does estradiol (the compound in question 23) have?

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

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25. Consider the following standard reduction potentials for the next question.

	E^0_{red}
$Li^+ + e^- \rightarrow Li$	−3.05 V
$Al^{3+} + 3\,e^- \rightarrow Al$	−1.66 V
$Fe^{2+} + 2\,e^- \rightarrow Fe$	−0.44 V
$Cu^{2+} + 2\,e^- \rightarrow Cu$	0.34 V
$Cl_2 + 2\,e^- \rightarrow 2\,Cl^-$	1.36 V

Which of the following can reduce Cu^{2+} to Cu but not reduce Al^{3+} to Al (assuming standard conditions)?

a) Li b) Li^+ c) Cl^- d) Fe^{2+} e) Fe

26. The reduction half-reaction for an unknown metal ion is:

$$M^{2+} + 2\,e^- \rightarrow M \quad E^\circ_{red} = ?$$

When a standard galvanic cell is set up such that the cell reaction is:

$$2Al^{3+} + 3\,M \rightarrow 3\,M^{2+} + 2\,Al$$

the measured cell potential is 0.71 V.

Given:

$$Al^{3+} + 3\,e^- \rightarrow Al \quad E^\circ_{red} = -1.66\ V$$

calculate the standard reduction potential for M^{2+} ($E^\circ_{red} = ?$).

a) –2.37 V b) –0.95 V c) 0.95 V d) 2.37 V

27. Calculate $\Delta G°$ for the galvanic cell described in the previous question (question 26).

a) 206 kJ b) –411 kJ c) –103 kJ d) 411 kJ e) –206 kJ

28. The solubility product for CuI(s) is 1.1×10^{-12} :

$$CuI(s) \rightleftharpoons Cu^+(aq) + I^-(aq) \quad K_{sp} = 1.1 \times 10^{-12}$$

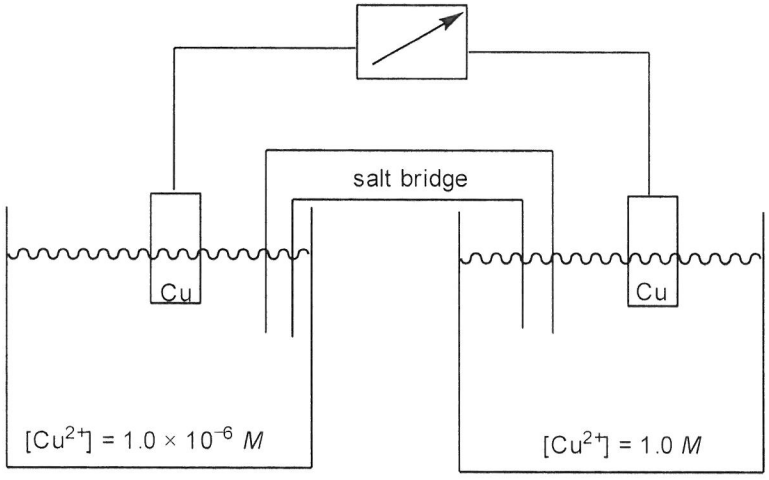
Given: $Cu^+(aq) + e^- \rightarrow Cu(s)$ $E^\circ_{red} = 0.52$ V,

calculate the standard reduction potential for the half-reaction:

$$CuI(s) + e^- \rightarrow Cu(s) + I^-(aq) \quad E^\circ_{red} = ?$$

a) 0.00 V b) 0.26 V c) 1.23 V d) –0.19 V e) –0.34 V

29. Consider the concentration cell at 25°C:



Which of the following statements concerning this concentration cell is **false**?

$Cu^{2+} + 2e^- \rightarrow Cu \qquad E^\circ_{red} = 0.34\ V$

a) Decreasing the concentration of Cu^{2+} at the anode will increase the cell potential.
b) Anions flow through the salt bridge into the container with $[Cu^{2+}] = 1.0 \times 10^{-6}\ M$.
c) $E_{cell} = -0.0591 \log (1.0 \times 10^{-6}) = 6(0.0591)$ volts
d) $E^\circ_{cell} = 0.0\ V$
e) The container with $[Cu^{2+}] = 1.0\ M$ is the cathode.

30. Consider the following reduction potentials:

	E_{red}
$F_2(g) + 2\ e^- \rightarrow 2\ F^-$	2.87 V
$O_2(g) + 4H^+ + 4\ e^- \rightarrow 2\ H_2O(l)$	0.82 V
$Ni^{2+} + 2\ e^- \rightarrow Ni(s)$	−0.23 V
$2\ H_2O(l) + 2\ e^- \rightarrow H_2(g) + 2\ OH^-$	−0.41 V

An aqueous solution of nickel fluoride (NiF_2) is electrolyzed. Which of the following statements **correctly** describes what will be observed?

a) $F_2(g)$ is produced at the cathode.
b) Ni(s) is deposited at the anode.
c) $H_2(g)$ is produced at the cathode.
d) $O_2(g)$ is produced at the anode.

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

a) Cars rust more easily in the arid (dry) climates of the southwest United States as compared to cars in the humid conditions of the midwest United States.
b) A sacrificial metal (also called cathodic protection) protects iron from corrosion because the sacrificial metal is more easily oxidized than iron.
c) The anode reaction in the corrosion of steel is the oxidation of Fe.
d) Paint and protective oxides prevent corrosion by eliminating contact of iron with oxygen and moisture.
e) Driving on roads which have been salted can increase the severity of corrosion.

32. Which of the following statements about liquids is **true**?

a) For the process of sublimation, $\Delta H_{sublimation}$ is a negative value (sublimation is a exothermic process).
b) For $H_2O(s)$, as pressure increases, the melting point temperature decreases.
c) As the external pressure increases, the boiling point of a liquid decreases.
d) More hydrogen bonding interactions are broken when water melts than when water boils.
e) For a group of compounds at 25°C, the compound with the strongest intermolecular forces will have the highest vapor pressure.

33. When toluene reacts with Cl_2 in the presence of $FeCl_3$, how many different monochlorination products are possible?

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

USEFUL CONSTANTS AND RELATIONS:

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

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

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

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

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

$Volt = J/Coul$

$$E = E^\circ - \frac{RT}{nF} \ln Q$$

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

$$\Delta G^\circ_{rxn} = \Sigma \Delta G^\circ_{f,\ products} - \Sigma \Delta G^\circ_{f,\ reactants}$$

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

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

$\Delta G = -nFE$

$\Delta G^\circ = -nFE^\circ$

$\Delta G^\circ = -RT \ln K$

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

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

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

$Amp = Coul/sec$

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

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

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

$K_w = 1.0 \times 10^{-14}$ (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}
$HC_3H_5O_2$	1.3×10^{-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:

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

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

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

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												3A	4A	5A	6A	7A	8A
1 H 1.008	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											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)