

**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 ( $E_{\text{cell}} > 0$ ).
  - d) In a galvanic cell, the anode is where reduction occurs.
  - e) None of the above statements (a-d) is true.

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

	<b><math>E^\circ</math> (volts)</b>
$\text{Ag}^{2+} + e^- \rightarrow \text{Ag}^+$	+1.99
$\text{Cl}_2 + 2e^- \rightarrow 2 \text{Cl}^-$	+1.36
$\text{Ag}^+ + 2e^- \rightarrow \text{Ag}$	+0.80
$\text{Cu}^{2+} + 2e^- \rightarrow \text{Cu}$	+0.34
$\text{Pb}^{2+} + 2e^- \rightarrow \text{Pb}$	-0.13
$\text{Ni}^{2+} + 2e^- \rightarrow \text{Ni}$	-0.23
$\text{Fe}^{2+} + 2e^- \rightarrow \text{Fe}$	-0.44
$\text{Mg}^{2+} + 2e^- \rightarrow \text{Mg}$	-2.37

2. The ionic compound  $\text{AgCl}_2$  is unstable. Which of the following best explains why  $\text{AgCl}_2$  is unstable?
- a)  $\text{Ag}^{2+}$  will oxidize  $\text{Cl}^-$  making  $\text{AgCl}_2$  unstable.
  - b)  $\text{Ag}^{2+}$  will oxidize  $\text{Cl}_2$  making  $\text{AgCl}_2$  unstable.
  - c)  $\text{Ag}^+$  will oxidize  $\text{Cl}_2$  making  $\text{AgCl}_2$  unstable.
  - d)  $\text{Ag}^+$  will oxidize  $\text{Cl}^-$  making  $\text{AgCl}_2$  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:  $\text{Al} \mid \text{Al}^{3+} (0.10 \text{ M}) \parallel \text{Al}^{3+} (1.5 \text{ M}) \mid \text{Al}$

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

- a) No effect.
- b)  $E_{\text{cell}}$  would decrease.
- c)  $E_{\text{cell}}$  would increase.

5. A galvanic cell has a K value equal to 1.00. The cell reaction:
- has a negative  $\Delta G^\circ$  value.
  - has  $\Delta G^\circ = 0$ .
  - has a positive  $E_{\text{cell}}^\circ$  value.
  - has a negative  $E_{\text{cell}}^\circ$  value.
  - None of these answers (a-d) are true.

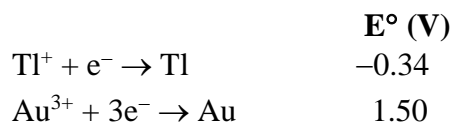
6. Given:

	$E^\circ$ (V)
$\text{O}_2 + 4 \text{H}^+ + 4\text{e}^- \rightarrow 2 \text{H}_2\text{O}$	+0.82
$\text{I}_2 + 2\text{e}^- \rightarrow 2 \text{I}^-$	+0.54
$2 \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2 \text{OH}^-$	-0.41
$\text{Cr}^{3+} + 3\text{e}^- \rightarrow \text{Cr}$	-0.73

Consider the electrolysis of an aqueous solution of chromium iodide ( $\text{CrI}_3$ ). Using the potentials above, which of the following statements describes what should be observed? Assume no overvoltage and assume standard conditions.

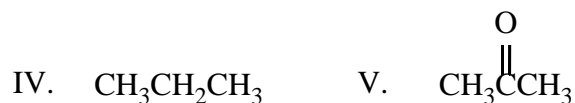
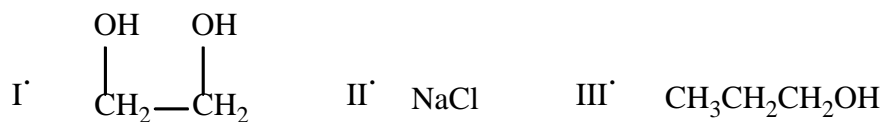
- $\text{I}^-$  will be produced at one electrode and  $\text{H}_2\text{O}$  will be produced at the other electrode.
  - $\text{I}_2$  will be produced at one electrode and Cr will be produced at the other electrode.
  - $\text{I}_2$  will be produced at one electrode and  $\text{H}_2$  and  $\text{OH}^-$  will be produced at the other electrode.
  - $\text{O}_2$  and  $\text{H}^+$  will be produced at one electrode Cr will be produced at the other electrode.
  - $\text{O}_2$  and  $\text{H}^+$  will be produced at one electrode and  $\text{H}_2$  and  $\text{OH}^-$  will be produced at the other electrode.
7. Which of the following statements is **false**?
- Driving on roads which have been salted can increase the severity of corrosion.
  - Protective oxides can prevent corrosion by eliminating contact of the metal with oxygen and moisture.
  - Corrosion involves the oxidation of iron.
  - Corrosion is an example of an electrolytic process.
  - 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:



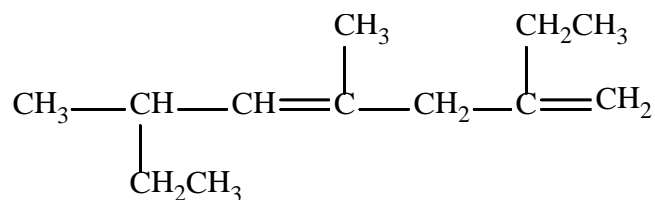
Calculate the cell potential at 25°C when  $[\text{Au}^{3+}] = 1.0 \times 10^{-2} \text{ M}$  and  $[\text{Tl}^+] = 1.0 \times 10^{-4} \text{ M}$ .

- 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).



- a)  $\text{II} < \text{IV} < \text{V} < \text{III} < \text{I}$     b)  $\text{IV} < \text{V} < \text{III} < \text{I} < \text{II}$     c)  $\text{IV} < \text{III} < \text{I} < \text{V} < \text{II}$   
d)  $\text{II} < \text{I} < \text{III} < \text{V} < \text{IV}$     e)  $\text{IV} < \text{V} < \text{III} < \text{II} < \text{I}$
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  $\text{sp}^3$  hybridized.  
d) Cycloalkanes can exhibit cis/trans isomerism.  
e) Alkanes can rotate about every bond.

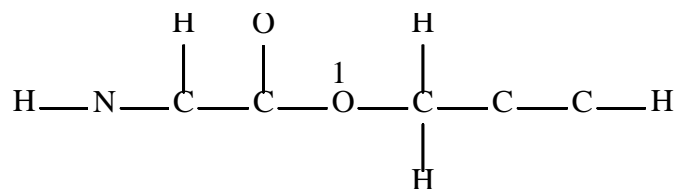
11. What is the IUPAC name for the following compound? (ignore cis/trans isomers)



- 2-ethyl-4,6-dimethyl-1,4-octadiene
- 2,6-diethyl-4-methyl-1,4-heptadiene
- 7-ethyl-3,5-dimethyl-4,7-octadiene
- 2,6-diethyl-4-methyl-3,6-heptadiene
- 3,5,7-trimethyl-4-nonene

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



- How many  $\pi$  bonds does this molecule have?
    - 0
    - 1
    - 2
    - 3
    - 4
  - What is the bond angle about the oxygen atom labeled 1?
    - $60^\circ$
    - $90^\circ$
    - $109^\circ$
    - $120^\circ$
    - $180^\circ$
  - How many nitrogen and carbon atoms are  $sp^2$  hybridized?
    - 1
    - 2
    - 3
    - 4
    - 5 (Five nitrogen and carbon atoms in this molecule exhibit  $sp^2$  hybridization.)
  - 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?
    - 0
    - 1
    - 2
    - 3
    - 4
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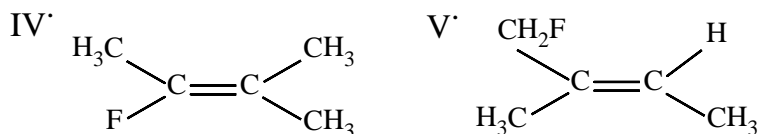
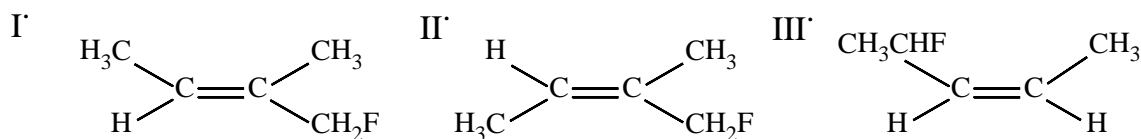
16. Which of the following organic compounds will decolorize a bromine solution?
- benzene
  - 2-methylbutane
  - cycloheptane
  - trans-4-methyl-2-pentene
  - toluene
17. In class, the absent-minded professor carelessly named an organic compound, 2-3-dibromo-2,3-diisopropylbutane. An ever alert student 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?
- 2,3-dibromo-1,1,2,3,4,4-hexamethylbutane
  - 3,4-dibromo-2,3-dimethyl-4-isopropylpentane
  - 3,4-dibromo-2-methyl-5-isopropylhexane
  - 3,4-dibromo-2,3,4,5-tetramethylhexane
  - 2,3-dibromo-5-methyl-2-isopropylpentane
18. Consider the combustion reaction of toluene. How many molecules of O<sub>2</sub> are required to react with each molecule of toluene?
- 2.5
  - 5
  - 7.5
  - 8
  - 9
19. How many different monochlorination products can be produced for the reaction shown below?
- $$\text{CH}_3\text{---CH}_2\text{---}\overset{\text{CH}_3}{\underset{|}{\text{CH}}}\text{---CH}_2\text{---CH}_3 + 1 \text{ Cl}_2 \xrightarrow{h\nu} ? + \text{HCl}$$
- 2
  - 3
  - 4
  - 5
  - 6
20. Bromochloropropene (C<sub>3</sub>H<sub>4</sub>BrCl) exhibits structural, geometric and optical isomerism. How many of the eight noncyclic structural isomers for bromochloropropene are optically active? **Note:** ignore cyclic structures.
- 1
  - 2
  - 3
  - 4
  - 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<sub>3</sub>OH) 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:



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  $\pi$  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  $\pi$  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)  $\text{Be}_2$     b)  $\text{H}_2$     c)  $\text{He}_2^+$     d)  $\text{H}_2^-$     e)  $\text{Li}_2$
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.