Instructions: You should have with you several number two pencils, an eraser, your 3” x 5” note card, a calculator, and your University ID Card. If you have notes with you, place them in a sealed backpack and place the backpack OUT OF SIGHT or place the notes directly on the table at the front of the room.

Fill in the front page of the Scantron answer sheet with your class section number (see below), last name, first name, middle initial, and student identification number. Leave the test form number blank.

Section 001 (MWF 8am with Dr. Nafshun)
Section 002 (MWF 9am with Dr. Nafshun)
Section 003 (MWF 11am with Dr. Watson)
Section 004 (MWF 1pm with Dr. Burrows)
Section 005 (MWF 2pm with Dr. Grajczyk)

This exam consists of 32 multiple-choice questions; each has 5 points attached. When you finish this exam, proceed to the proctor. Show your OSU ID Card and submit your completed Scantron form. You may take your notecard and this exam packet with you.

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<tr>
<th>Acid (aq)</th>
<th>Ka (M)</th>
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First-Order

\[ \ln [A] = -kt + \ln [A]_0 \]

\[ t_{1⁄2} = \frac{\ln (2)}{k} \]

\[ \ln \left( \frac{A}{A_0} \right) = -kt \]
Spectrochemical series:  $\text{CN}^- > \text{NO}_2^- > \text{en} > \text{NH}_3 > \text{NCS}^- > \text{H}_2\text{O} > \text{OH}^- > \text{F}^- > \text{Cl}^-$
R = 8.314 J/mol·K
\( N_A = 6.022 \times 10^{23} \)
h = 6.626 \times 10^{-34} J·s/photon

c = 3.00 \times 10^8 m/s
\( K = {}^\circ C + 273.15 \)
E = \( \frac{hc}{\lambda} \)

![The Standard Molar Enthalpies of Selected Substances at 298.15 K (25°C)]

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<tr>
<th>Compound</th>
<th>( S_m^{\circ} ) J/K·mol⁻¹</th>
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<th>( S_m^{\circ} ) J/K·mol⁻¹</th>
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\[ F = 96,485 \text{ C/mole e}^- \]
\[ R = 8.314 \text{ J/mol·K} \]
\[ N_A = 6.022 \times 10^{23} \]

\[ h = 6.626 \times 10^{-34} \text{ J·s/photon} \]
\[ \Delta G^{\circ \text{rxn}} = -RT \ln K \]

\[ \ln K = -\frac{\Delta H^{\circ \text{rxn}}}{R} \left(\frac{1}{T}\right) + \frac{\Delta S^{\circ \text{rxn}}}{R} \]
\[ \Delta G_{\text{rxn}} = \Delta G^{\circ \text{rxn}} + RT \ln Q \]
\[ c = 3.00 \times 10^8 \text{ m/s} \]

\[ E_{\text{cell}} = E_{\text{o cell}} - \frac{RT}{nF} \ln Q \]
\[ \Delta G^o = -nF E_{\text{o cell}} \]
\[ \Delta G = \Delta H - T\Delta S \]

\[ k = 1.381 \times 10^{-23} \text{ J/K} \]
\[ K = {}^\circ C + 273.15 \]
\[ E = \frac{hc}{\lambda} \]

\[ t_{1/2} [^{14}\text{C}] = 5730 \text{ y} \]
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<td>$\text{O}_3\text{(g)} + 2 \text{H}^+(\text{aq}) + 2 e^- \rightarrow \text{O}_2 \text{(g)} + \text{H}_2\text{O(}l)$</td>
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<tr>
<td>$\text{H}_2\text{O}_2 \text{(aq)} + 2\text{H}^+ \text{(aq)} + 2 e^- \rightarrow 2 \text{H}_2\text{O(}l)$</td>
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<tr>
<td>$\text{MnO}_4^- \text{(aq)} + 8\text{H}^+ \text{(aq)} + 5 e^- \rightarrow \text{Mn}^{2+} \text{(aq)} + 4 \text{H}_2\text{O(}l)$</td>
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<td>+1.455</td>
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<td>$\text{Cl}_2 \text{(g)} + 2 e^- \rightarrow 2 \text{Cl}^- \text{(aq)}$</td>
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<td>$\text{Cr}_2\text{O}_7^{2-} \text{(aq)} + 14 \text{H}^+ \text{(aq)} + 6 e^- \rightarrow 2 \text{Cr}^{3+} \text{(aq)} + 7 \text{H}_2\text{O(}l)$</td>
<td>+1.33</td>
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<tr>
<td>$\text{MnO}_2 \text{(s)} + 4\text{H}^+ \text{(aq)} + 2 e^- \rightarrow \text{Mn}^{2+} \text{(aq)} + 2 \text{H}_2\text{O(}l)$</td>
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<td>$2 \text{IO}_3^- \text{(aq)} + 12\text{H}^+ \text{(aq)} + 10 e^- \rightarrow \text{I}_2 \text{(s)} + 6 \text{H}_2\text{O(}l)$</td>
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<td>$\text{Br}_2 \text{(l)} + 2 e^- \rightarrow 2 \text{Br}^- \text{(aq)}$</td>
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<td>$\text{NO}_3^- \text{(aq)} + 4\text{H}^+ \text{(aq)} + 3 e^- \rightarrow \text{NO} \text{(g)} + 2 \text{H}_2\text{O(}l)$</td>
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<td>$\text{Ag}^+ \text{(aq)} + e^- \rightarrow \text{Ag} \text{(s)}$</td>
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<td>$\text{Fe}^{3+} \text{(aq)} + e^- \rightarrow \text{Fe}^{2+} \text{(aq)}$</td>
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<tr>
<td>$\text{O}_2 \text{(g)} + 2\text{H}^+ \text{(aq)} + 2 e^- \rightarrow \text{H}_2\text{O}_2 \text{(aq)}$</td>
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<td>$\text{I}_2 \text{(s)} + 2 e^- \rightarrow 2 \text{I}^- \text{(aq)}$</td>
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<tr>
<td>$\text{I}_2^- \text{(aq)} + 2 e^- \rightarrow 3 \text{I}^- \text{(aq)}$</td>
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<td>$\text{Cu}^{2+} \text{(aq)} + 2 e^- \rightarrow \text{Cu} \text{(s)}$</td>
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<td>$\text{SO}_4^{2-} \text{(aq)} + 4\text{H}^+ \text{(aq)} + 2 e^- \rightarrow 2 \text{H}_2\text{O(}l) + \text{SO}_2 \text{(g)}$</td>
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<td>$\text{Li}^+ \text{(aq)} + e^- \rightarrow \text{Li} \text{(s)}$</td>
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<td><strong>Basic Solution</strong></td>
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<td>$\text{O}_3 \text{(g)} + \text{H}_2\text{O(l)} + 2 e^- \rightarrow \text{O}_2 \text{(g)} + 2 \text{OH}^- \text{(aq)}$</td>
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The Periodic Table of the Elements

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1. A student titrates 2.884 g of an unknown monoprotic acid to the equivalence point with 62.55 mL of 0.2447 M NaOH (aq). What is the molar mass of the acid?

(A) 0.005307 g/mol
(B) 53.07 g/mol
(C) 530.7 g/mol
(D) 73.72 g/mol
(E) 188.4 g/mol

2. Consider the reaction of NH$_3$ and water. The conjugate acid is:

(A) H$_2$O
(B) NH$_3$
(C) CH$_3$COO$^-$
(D) H$^+$
(E) NH$_4^+$

3. The pH of a buffer system which is 0.450 M HCOOH (aq) and 0.225 M HCOONa (aq) is:

(A) 3.60 x 10$^{-4}$
(B) 4.05
(C) 9.00 x 10$^{-4}$
(D) 9.00 x 10$^{-5}$
(E) 3.44
4. What is the molar solubility of Al(OH)$_3$ (aq)? [\(K_{sp} \) of Al(OH)$_3$ is $1.3 \times 10^{-33}$]

(A) $3.6 \times 10^{-12}$ M  
(B) $2.6 \times 10^{-9}$ M  
(C) $4.6 \times 10^{-5}$ M  
(D) $3.6 \times 10^{-17}$ M  
(E) $2.9 \times 10^{-10}$ M

5. Which of the following is NOT a Lewis base?

(A) OH$^-$  
(B) F$^-$  
(C) C$_2$O$_4^{2-}$  
(D) Cu$^{2+}$  
(E) NH$_3$

6. The concentration of NaOH in water is gradually increased without changing the volume significantly. Which of the following describes what happens to the concentrations of H$_3$O$^+$ and OH$^-$, the pH and the pOH?

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<th></th>
<th>Concentration of H$_3$O$^+$</th>
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<td>(E)</td>
<td>decreases</td>
<td>increases</td>
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<td>decreases</td>
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</table>
7. What is the coordination number of the metal ion in \([\text{Co(en)}_2(\text{ox})]\)?

(A) 0  
(B) 2  
(C) 4  
(D) 6  
(E) 8

8. The splitting of the d orbitals in a transition metal complex is 171 kJ/mol. What color does this transition metal complex appear to be in transmission?

(A) green  
(B) blue  
(C) violet  
(D) red  
(E) orange

9. Which of the following statements is true about the octahedral complex \([\text{Mn(CN)}_6]^{4-}\)?

(A) The complex is low spin with no unpaired electrons  
(B) The complex is low spin with one unpaired electron  
(C) The complex is low spin with five unpaired electrons  
(D) The complex is high spin with one unpaired electron  
(E) The complex is high spin with five unpaired electrons
10. Which of the following processes have a \( \Delta S > 0 \)?

(A) \( \text{CH}_3\text{OH}(l) \rightarrow \text{CH}_3\text{OH}(s) \)
(B) \( \text{N}_2(g) + 3 \text{H}_2(g) \rightarrow 2 \text{NH}_3(g) \)
(C) \( \text{CH}_4(g) + \text{H}_2\text{O}(g) \rightarrow \text{CO}(g) + 3 \text{H}_2(g) \)
(D) \( \text{Na}_2\text{CO}_3(s) + \text{H}_2\text{O}(g) + \text{CO}_2(g) \rightarrow 2 \text{NaHCO}_3(s) \)
(E) All of the above processes have a \( \Delta S > 0 \).

11. Consider a reaction that has a negative \( \Delta H \) and a positive \( \Delta S \). Which of the following statements is **TRUE**?

(A) This reaction will be spontaneous only at low temperatures.
(B) This reaction will be spontaneous at all temperatures.
(C) This reaction will be nonspontaneous at all temperatures.
(D) This reaction will be nonspontaneous only at low temperatures.
(E) All of the above

12. Determine the equilibrium constant for a process at 954 K in which \( \Delta H_{sys}^\circ = -90.8 \text{ kJ/mol} \) and \( \Delta S_{sys}^\circ = 102.6 \text{ J/mol·K} \)

(A) 481
(B) \( 1.07 \times 10^9 \)
(C) \( 2.08 \times 10^{-3} \)
(D) \( 2.14 \times 10^{10} \)
(E) \( 1.94 \times 10^{12} \)
13. When the reaction \( \text{Mo (s)} + \text{Cr}_2\text{O}_7^{2-} (\text{aq}) \rightarrow \text{Cr}^{2+} (\text{aq}) + \text{Mo}^{4+} (\text{aq}) \) is correctly balanced in acid,

- (A) 4 protons (H\(^+\)) are consumed
- (B) 8 protons (H\(^+\)) are consumed
- (C) 12 protons (H\(^+\)) are consumed
- (D) 14 protons (H\(^+\)) are consumed
- (E) 40 protons (H\(^+\)) are consumed

14. An electrochemical cell consists of one beaker containing 1.0 M AgNO\(_3\)(aq) into which dips a piece of metallic silver and a second beaker containing 1.0 M Zn(NO\(_3\))\(_2\)(aq) into which dips a piece of metallic zinc. The beakers are connected by a salt bridge containing 1.0 M KNO\(_3\)(aq). Which of the following statements will be \textbf{TRUE} when a wire is connected between the two pieces of metal at 298 K?

- (A) Electrons will flow from the silver to the zinc.
- (B) The cell voltage will be +0.04 V.
- (C) There will be no cell voltage as the overall reaction is non-spontaneous.
- (D) The silver will plate out on the zinc.
- (E) The value of \( n \) used to find \( \Delta G^\circ \) for this cell has the value 2.

15. A student provides a current of 1.500 amps through an aqueous solution of Cu(NO\(_3\))\(_2\) for 7.000 hours. The voltage is such that copper is deposited at the cathode. The mass of copper deposited is:

- (A) 0.0804 g
- (B) 0.1608 g
- (C) 6.222 g
- (D) 12.45 g
- (E) 24.89 g
16. A student constructs a voltaic cell from zinc metal and Zn(NO$_3$)$_2$ (aq) and lead metal and Pb(NO$_3$)$_2$ (aq). Which one of the following changes to the cell would cause the cell potential to increase?

(A) Increase the Zn(NO$_3$)$_2$ (aq) concentration
(B) Increase the Pb(NO$_3$)$_2$ (aq) concentration
(C) Increase the mass of Zn(s)
(D) Decrease the mass of Zn(s)

17. Using reduction half-reaction potentials, calculate $\Delta G^\circ$ for the following balanced redox reaction:

$$3 \text{I}_2 (s) + 2 \text{Al} (s) \rightarrow 2 \text{Al}^{3+} (aq) + 6 \text{I}^- (aq)$$

(A) $-1.28 \times 10^3$ kJ
(B) -213 kJ
(C) $-2.21 \times 10^3$ kJ
(D) -2.21 kJ
(E) -640 kJ

18. Which of the following statements is **FALSE**?

(A) Positron emission can be seen as p$\rightarrow$n + e$^+$
(B) Electron capture can be seen as p + e$^-$ $\rightarrow$n
(C) When a beta particle is emitted, an electron is converted to a proton
(D) When an alpha particle is emitted, a helium nucleus is lost from the nucleus of the parent species
(E) A photon is emitted during gamma emission
Consider the figure below. A nuclide in “Region 1” will likely undergo _______ decay and a nuclide in “Region 2” will likely undergo _______ decay.

(A) alpha; beta
(B) beta; alpha
(C) alpha; electron capture
(D) electron capture; alpha
(E) beta; positron
20. Which of the following is NOT a structural isomer of 2-methyl-3-ethylheptane?

(A) 5-methylnonane
(B) 2-methyl-4-ethylheptane
(C) 2,2,3,4,4-pentamethylpentane
(D) 2,4-diethyl-3-isopropylpentane
(E) decane

21. An amine and carboxylic acid are reacted together in a condensation reaction. The product is:

(A) an alcohol
(B) hydrogen peroxide
(C) an amide
(D) an ester
(E) a ketone

22. The addition reaction of 1-hexene and HBr produces:

(A) 1-hexane
(B) 1-bromohexane
(C) 2-hexane
(D) 1-methylhexane
(E) 2-bromohexane
23. Which of the following lipids will have the lowest melting point?

![Chemical structures](image)

a) ![Chemical structure](image)  

b) ![Chemical structure](image)  

c) ![Chemical structure](image)  

d) ![Chemical structure](image)

24. Xylose, or wood sugar, is one of eight essential sugars for human nutrition. What is the systematic name of this carbohydrate?

![Chemical structure](image)

(A) ketohexose  
(B) aldohexose  
(C) aldopentose  
(D) ketopentose  
(E) ketotetrose
25. Which of the following is a disaccharide?

![Disaccharide Options]

26. Which of the following is NOT an example of a secondary protein structure?
   (A) Globular structures such as the four units composing hemoglobin
   (B) α-helix
   (C) β-pleated sheet
   (D) All of the above are secondary protein structures
   (E) None of the above are secondary protein structures

27. Which of the following is responsible for linking two strands of DNA in an α-helix?
   (A) Ester linkages
   (B) Hydrogen bonds
   (C) Glycosidic linkages
   (D) Peptide bonds
   (E) Disulfide linkages
The structure of Corticosterone is shown below.

Corticosterone **DOES NOT** contain:

(A) an alcohol group  
(B) an alkene group  
(C) a ketone group  
(D) an ether group  
(E) a methyl group

29. Which of the following is a secondary alcohol?

(A) 3-heptanol  
(B) 2-methyl-2-heptanol  
(C) 1-ethanol  
(D) 1-heptanol  
(E) 2,3-dimethyl-1-heptanol

30. Which of the following is **FALSE**?

(A) A condensation polymer, such as a polyamide, can be formed from a diamine and a dicarboxylic acid  
(B) Polymers are long chains formed by monomer units  
(C) Addition polymerization is common in alkanes  
(D) Teflon is a fluorine containing polymer  
(E) Low density polymers are typically more flexible and porous than high density polymers
31. Amino acids can be linked together with _______ to form _______.
   (A) ester bonds; proteins
   (B) ester bonds; carbohydrates
   (C) ester bonds; polysaccharides
   (D) amide bonds; polysaccharides
   (E) amide bonds; proteins

32. What is the product for the dehydration of CH₃CH₂CH₂OH?
   (A) CH₃CH₂CH₂OCH₂CH₂CH₃
   (B) CH₃CH=CH₂
   (C) CH₃CH=CHCH₃
   (D) CH₃CH₂CH=CH₂
   (E) CH₂=C=CH₂