Chemistry 233	Spring 2014	Oregon State University
Final Exam	June 10, 2014	Drs. Nafshun, Watson, Burrows, Grajczyk

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.

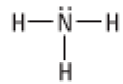
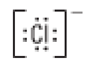
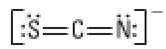
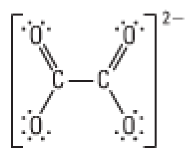
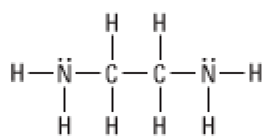
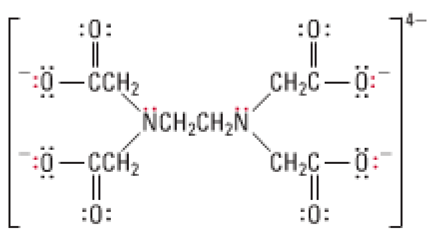
Fill in the front page of the Scantron answer sheet with your class section number (see below), last name, first name, middle initial, and student identification number. Leave the test form number blank.

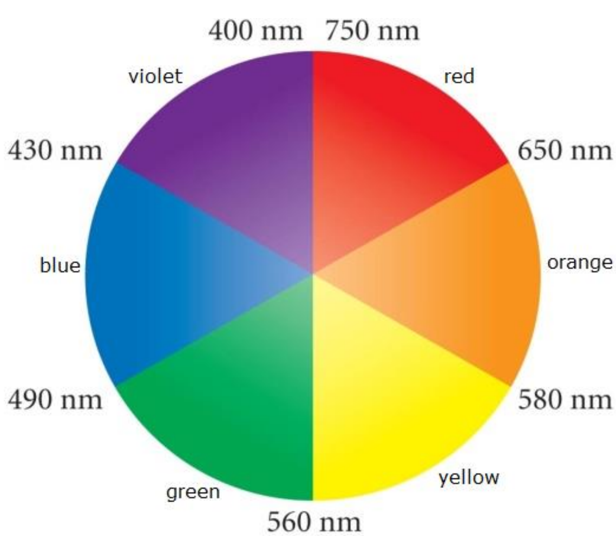
Section 001 (MWF 8am with Dr. Nafshun)
Section 002 (MWF 9am with Dr. Nafshun)
Section 003 (MWF 11am with Dr. Watson)
Section 004 (MWF 1pm with Dr. Burrows)
Section 005 (MWF 2pm with Dr. Grajczyk)

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.

$K_a[CH_3COOH\ (aq)] = 1.80 \times 10^{-5}$ (acetic acid)	$K_a[C_6H_5COOH\ (aq)] = 6.30 \times 10^{-5}$ (benzoic acid)
$K_a[CH_2ClCOOH\ (aq)] = 1.40 \times 10^{-3}$ (chloroacetic acid)	$K_b[NH_3\ (aq)] = 1.80 \times 10^{-5}$ (ammonia)
$K_a[HClO\ (aq)] = 2.90 \times 10^{-8}$ (hypochlorous acid)	$K_a[CH_3CH_2CH_2CH_2COOH\ (aq)] = 1.45 \times 10^{-5}$ (pentanoic acid)
$K_a[HF\ (aq)] = 6.30 \times 10^{-4}$ (hydrofluoric acid)	$K_b\ [CH_3NH_2] = 3.70 \times 10^{-4}$ (methylamine)
$K_a[HCOOH\ (aq)] = 1.80 \times 10^{-4}$ (formic acid)	$K_{sp}\ [Fe(OH)_2] = 4.87 \times 10^{-17}$
$K_{sp}\ [PbF_2] = 3.6 \times 10^{-8}$	$K_{sp}\ [MgF_2] = 3.7 \times 10^{-8}$
$K_{sp}\ [Cd(OH)_2] = 7.2 \times 10^{-15}$	$K_{sp}\ [PbI_2] = 1.4 \times 10^{-8}$
$K_{sp}\ [CaSO_4] = 2.4 \times 10^{-5}$	$K_{sp}\ [CaC_2O_4] = 2.3 \times 10^{-9}$
$K_{sp}\ [CuCl] = 1.0 \times 10^{-6}$	$K_{sp}\ [AgCl] = 1.77 \times 10^{-10}$
$K_{sp}\ [Ag_2CO_3] = 8.1 \times 10^{-12}$	

First-Order		
$\ln [A] = -kt + \ln [A]_0$	$t_{\frac{1}{2}} = \frac{\ln (2)}{k}$	$\ln \frac{A}{A_o} = -kt$

Water		Note: No Charge
Ammonia		Note: No Charge
Chloride ion		Note: Minus one charge
Carbon monoxide		Note: No Charge
Cyanide ion		Note: Minus one charge
Thiocyanate ion		Note: Minus one charge
Oxalate ion (ox)		Note: Minus two charge
Ethylenediamine (en)		Note: No Charge
Ethylenediaminetetraacetate (EDTA)		Note: Minus four charge



Spectrochemical series: $CN^- > NO_2^- > en > NH_3 > NCS^- > H_2O > OH^- > F^- > Cl^-$

$R = 8.314$ 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 $K = {}^{\circ}C + 273.15$ $E = hc/\lambda$

The Standard Molar Entropies of Selected Substances at 298.15 K (25°C)

Compound	S_m° /J K^{-1}mol^{-1}	Compound	S_m° /J K^{-1}mol^{-1}
Solids		**Diatomic Gases**	
C (diamond)	2.377		
C (graphite)	5.74	H_2	130.7
Si	18.8	D_2	145.0
Ge	31.1	HCl	186.9
Sn (gray)	44.1	HBr	198.7
Pb	64.8	HI	206.6
Li	29.1	N_2	191.6
Na	51.2	O_2	205.1
K	64.2	F_2	202.8
Rb	69.5	Cl_2	223.1
Cs	85.2	Br_2	245.5
NaF	51.5	I_2	260.7
MgO	26.9	CO	197.7
AlN	20.2	**Triatomic Gases**	
NaCl	72.1	H_2O	188.8
KCl	82.6	NO_2	240.1
Mg	32.7	H_2S	205.8
Ag	42.6	CO_2	213.7
I_2	116.1	SO_2	248.2
MgH_2	31.1	N_2O	219.9
AgN_3	99.2	O_3	238.9
Liquids		**Polyatomic Gases(> 3)**	
Hg	76.0	CH_4	186.3
Br_2	152.2	C_2H_6	229.6
H_2O	69.9	C_3H_8	269.9
H_2O_2	109.6	C_4H_{10}	310.2
CH_3OH	126.8	C_5H_{12}	348.9
C_2H_5OH	160.7	C_2H_4	219.6
C_6H_6	172.8	N_2O_4	304.3
BCl_3	206.3	B_2H_6	232.0
Monatomic Gases		BF_3	254.0
He	126.0	NH_3	192.5
Ne	146.2		
Ar	154.8		
Kr	164.0		
Xe	169.6		

$F = 96{,}485$ C/mole e$^-$ $R = 8.314$ J/mol·K $N_A = 6.022 \times 10^{23}$

$S = k \ln W$ $h = 6.626 \times 10^{-34}$ J·s/photon $\Delta G^{o}_{rxn} = -RT \ln K$

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

$E_{cell} = E^{\circ}_{cell} - \frac{RT}{nF} \ln Q$ $\Delta G^{o} = -nF E^{\circ}_{cell}$ $\Delta G = \Delta H - T\Delta S$

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

$t_{1/2}$ [^{14}C] = 5730 y

Reduction Half-Reaction	*E* º, volt
Acidic Solution	
F_2 (g) + 2 e^- → 2F^- (aq)	+2.866
O_3(g) + 2 H^+(aq) + 2 e^- → O_2 (g) + H_2O(l)	+2.075
$S_2O_8^{2-}$ (aq) + 2 e^- → 2 SO_4^{2-} (aq)	+2.01
H_2O_2 (aq) + 2H^+ (aq) + 2 e^- → 2 H_2O(l)	+1.763
MnO_4^-(aq) + 8H^+ (aq) + 5 e^- → Mn^{2+}(aq) + 4 H_2O(l)	+1.51
PbO_2 (s)+ 4H^+ (aq) + 2 e^- → Pb^{2+}(aq) + 2 H_2O(l)	+1.455
Cl_2 (g) + 2 e^- → 2 Cl^- (aq)	+1.358
$Cr_2O_7^{2-}$ (aq) + 14 H^+ (aq) + 6 e^- → 2 Cr^{3+}(aq) + 7 H_2O(l)	+1.33
MnO_2(s) + 4H^+ (aq) + 2 e^- → Mn^{2+}(aq) + 2 H_2O(l)	+1.23
O_2(g) + 4H^+ (aq) + 4 e^- → 2 H_2O(l)	+1.229
2 IO_3^- (aq) +12H^+ (aq) + 10 e^- → I_2(s) + 6 H_2O(l)	+1.20
Br_2(l) + 2 e^- → 2 Br^- (aq)	+1.065
NO_3^- (aq) + 4H^+ (aq) + 3 e^- → NO(g) + 2 H_2O(l)	+0.956
Ag^+ (aq) + e^- → Ag(s)	+0.800
Fe^{3+}(aq) + e^- → Fe^{2+}(aq)	+0.771
O_2(g) + 2H^+ (aq) + 2 e^- → H_2O_2(aq)	+0.695
I_2(s) + 2 e^- → 2 I^- (aq)	+0.535
I_3^-(aq) + 2 e^- → 3 I^- (aq)	+0.530
Cu^{2+}(aq) + 2 e^- → Cu(s)	+0.340
SO_4^{2-} (aq) + 4H^+ (aq) + 2 e^- → 2 H_2O(l) + SO_2(g)	+0.17
Sn^{4+} (aq) + 2 e^- → Sn^{2+} (aq)	+0.154
S(s) + 2H^+ (aq) + 2 e^- → H_2S(g)	+0.14
2H^+(aq) + 2 e^- → H_2(g)	0
Pb^{2+}(aq) + 2 e^- → Pb(s)	-0.125
Sn^{2+}(aq) + 2 e^- → Sn(s)	-0.137
Co^{2+}(aq) + 2 e^- → Co(s)	-0.277
Cr^{3+}(aq) + e^- → Cr^{2+}(aq)	-0.410
Fe^{2+}(aq) + 2 e^- → Fe(s)	-0.440
Zn^{2+}(aq) + 2 e^- → Zn(s)	-0.763
Al^{3+}(aq) + 3 e^- → Al(s)	-1.676
Mg^{2+}(aq) + 2 e^- → Mg(s)	-2.356
Na^+(aq) + e^- → Na (s)	-2.713
Ca^{2+}(aq) + 2 e^- → Ca(s)	-2.84
K^+(aq) + e^- → K(s)	-2.924
Li^+(aq) + e^- → Li(s)	-3.040
Basic Solution	
O_3(g) + H_2O(l) + 2 e^- → O_2(g) + 2 OH^-(aq)	+1.246
OCl^-(g) + H_2O(l) + 2 e^- → Cl^-(aq) + 2 OH^-(aq)	+0.890
O_2(g) + 2 H_2O(l) + 4 e^- → 4 OH^-(aq)	+0.401
2 H_2O(l) + 2 e^- → H_2(g) + 2 OH^-(aq)	-0.828

The Periodic Table of the Elements

1 **H** Hydrogen 1.00794																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012182											5 **B** Boron 10.811	6 **C** Carbon 12.0107	7 **N** Nitrogen 14.00674	8 **O** Oxygen 15.9994	9 **F** Fluorine 18.9984032	10 **Ne** Neon 20.1797
11 **Na** Sodium 22.989770	12 **Mg** Magnesium 24.3050											13 **Al** Aluminum 26.981538	14 **Si** Silicon 28.0855	15 **P** Phosphorus 30.973761	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.4527	18 **Ar** Argon 39.948
19 **K** Potassium 39.0983	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.955910	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.9415	24 **Cr** Chromium 51.9961	25 **Mn** Manganese 54.938049	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933200	28 **Ni** Nickel 58.6934	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92160	34 **Se** Selenium 78.96	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.80
37 **Rb** Rubidium 85.4678	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.90585	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.90638	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.90550	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.8682	48 **Cd** Cadmium 112.411	49 **In** Indium 114.818	50 **Sn** Tin 118.710	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90447	54 **Xe** Xenon 131.29
55 **Cs** Cesium 132.90545	56 **Ba** Barium 137.327	57 **La** Lanthanum 138.9055	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.9479	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.078	79 **Au** Gold 196.96655	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.3833	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98038	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (263)	107 **Bh** Bohrium (262)	108 **Hs** Hassium (265)	109 **Mt** Meitnerium (266)	110 (269)	111 (272)	112 (277)	113	114				

				58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.90765	60 **Nd** Neodymium 144.24	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.92534	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.93032	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.93421	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.967
				90 **Th** Thorium 232.0381	91 **Pa** Protactinium 231.03588	92 **U** Uranium 238.0289	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (262)

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_2O
(B) NH_3
(C) CH_3COO^-
(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) 3.60×10^{-4}
(B) 4.05
(C) 9.00×10^{-4}
(D) 9.00×10^{-5}
(E) 3.44

4. What is the molar solubility of $Al(OH)_3$ (aq)? [K_{sp} of $Al(OH)_3$ is 1.3×10^{-33}]

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

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

(A) OH^-
(B) F^-
(C) $C_2O_4^{2-}$
(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_3O^+ and OH^-, the pH and the pOH?

	Concentration of H_3O^+	**Concentration of OH^-**	**pH**	**pOH**
(A)	increases	increases	increases	decreases
(B)	increases	decreases	increases	decreases
(C)	decreases	increases	decreases	increases
(D)	decreases	decreases	decreases	increases
(E)	decreases	increases	increases	decreases

7. What is the coordination number of the metal ion in $[Co(en)_2(ox)]$?

(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 $[Mn(CN)_6]^{4-}$?

(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) $CH_3OH(l) \rightarrow CH_3OH(s)$
(B) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
(C) $CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$
(D) $Na_2CO_3(s) + H_2O(g) + CO_2(g) \rightarrow 2NaHCO_3(s)$
(E) All of the above processes have a $\Delta S > 0$.

11. Consider a reaction that has a negative ΔH and a positive ΔS. 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
$\Delta H_{sys}° = -90.8$ kJ/mol and $\Delta S_{sys}° = 102.6$ J/mol·K

(A) 481
(B) 1.07×10^{9}
(C) 2.08×10^{-3}
(D) 2.14×10^{10}
(E) 1.94×10^{12}

13. When the reaction Mo (s) + $Cr_2O_7^{2-}$ (aq) → Cr^{2+} (aq) + Mo^{4+} (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 **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 $\Delta G°$ 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 ΔG° for the following balanced redox reaction:

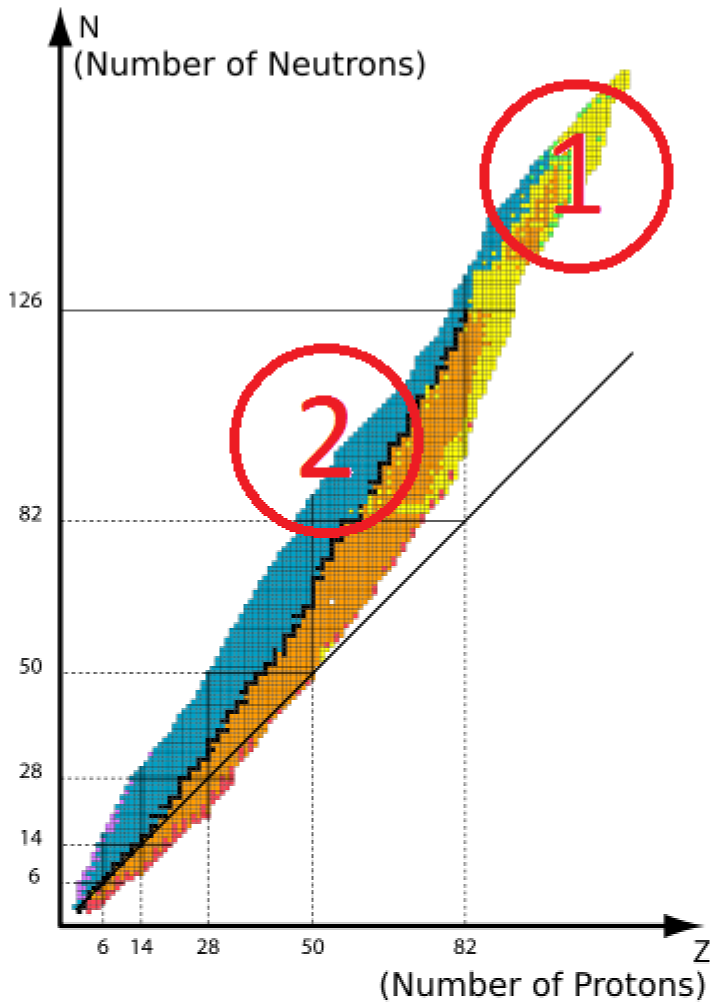
$3\ I_2\ (s) + 2\ Al\ (s) \rightarrow 2\ Al^{3+}\ (aq) + 6\ I^-\ (aq)$

(A) -1.28×10^3 kJ
(B) -213 kJ
(C) -2.21×10^3 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

19. 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

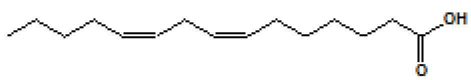
22. The addition reaction of 1-hexene and HBr produces:

(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?

a)

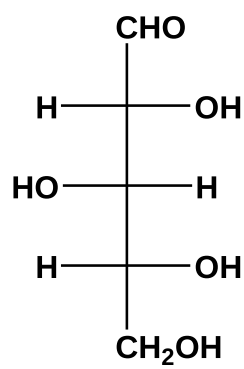
b)



c)

d)

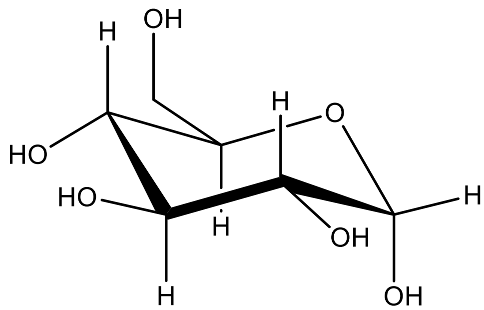
24. Xylose, or wood sugar, is one of eight essential sugars for human nutrition. What is the systematic name of this carbohydrate?

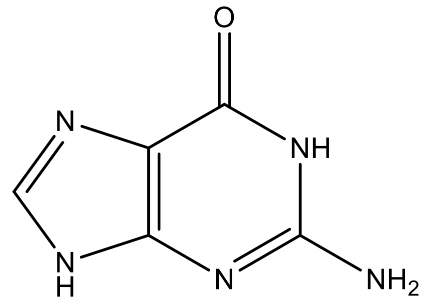


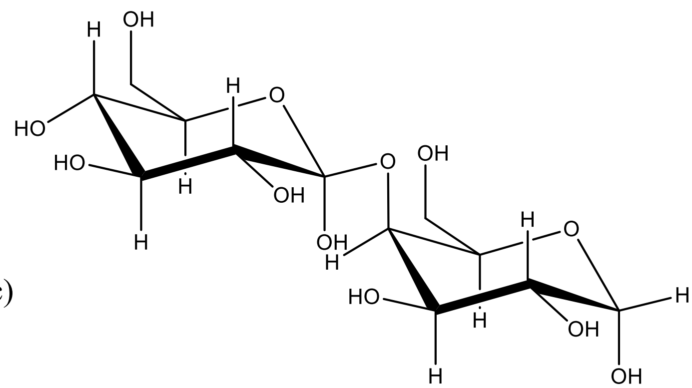
Xylose

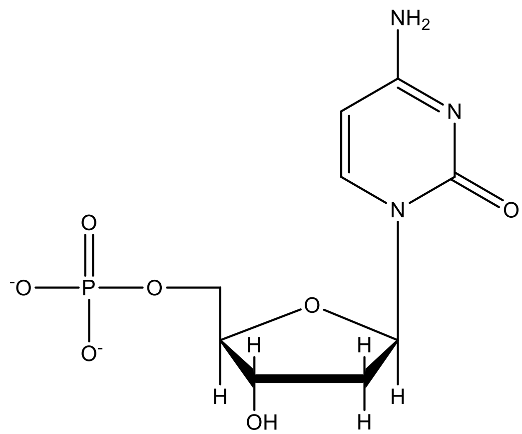
(A) ketohexose
(B) aldohexose
(C) aldopentose
(D) ketopentose
(E) ketotetrose

25. Which of the following is a disaccharide?

a) 

b) 

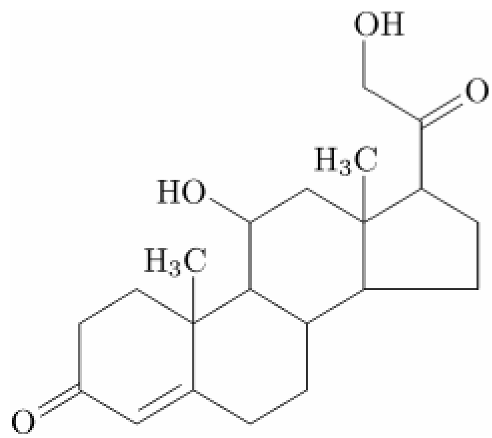
c) 

d) 

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

28. 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 $CH_3CH_2CH_2OH$?

(A) $CH_3CH_2CH_2OCH_2CH_2CH_3$
(B) $CH_3CH{=}CH_2$
(C) $CH_3CH{=}CHCH_3$
(D) $CH_3CH_2CH{=}CH_2$
(E) $CH_2{=}C{=}CH_2$