2015 Academic Challenge

CHEMISTRY TEST – STATE

This Test Consists of 40 Questions

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GENERAL DIRECTIONS

Please read the following instructions carefully. This is a timed test; any instructions from the test supervisor should be followed promptly.

The test supervisor will give instructions for filling in any necessary information on the answer sheet. Most Academic Challenge sites will ask you to indicate your answer to each question by marking an oval that corresponds to the correct answer for that question. One oval should be marked to answer each question. Multiple ovals will automatically be graded as an incorrect answer.

Be sure ovals are marked as ● , not ⊙ , ◐ , ◑ , etc.

If you wish to change an answer, erase your first mark completely before marking your new choice.

You are advised to use your time effectively and to work as rapidly as you can without losing accuracy. Do not waste your time on questions that seem too difficult for you. Go on to the other questions, and then come back to the difficult ones later if time remains.

***** Time: 40 Minutes *****

DO NOT OPEN TEST BOOKLET UNTIL YOU ARE TOLD TO DO SO!

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 Unq	105 Unp	106 Unh	107 Uns	108 Uno	109 Une									

*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)

Potentially Useful Information

$q = m \bullet c_s \bullet \Delta T$

$\Delta T_f = i \bullet K_f \bullet m$

$\Delta T_b = i \bullet K_b \bullet m$

$S_{gas} = k_H \bullet P_{gas}$

$P_{solvent} = X_{solvent} \bullet P°_{solvent}$

$k = Ae^{-Ea/RT}$

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

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

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

$\ln\left(\frac{k_2}{k_1}\right) = \frac{-E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$

$\ln\left(\frac{K_2}{K_1}\right) = \frac{-\Delta H_{rxn}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$

$\ln\left(\frac{P_2}{P_1}\right) = \frac{-\Delta H_{vap}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$

$pH = -\log [H_3O^+]$

$pOH = -\log [OH^-]$

$pH = pK_a + \log\left(\frac{[A^-]}{[HA]}\right)$

$\Delta S_{surr} = \frac{-\Delta H_{sys}}{T}$

$\Delta G° = \Delta H° - T\Delta S°$

$E_{cell}° = E_{red}° + E_{ox}°$

$\Delta E = B\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$

$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$\Delta G° = -nF\varepsilon°$

$c = \lambda\nu$

$\Pi = MRT$

$\Delta E = h\nu$

$F = 96485$ C/mol

$K_w = 1.0 \times 10^{-14}$

$R = 0.08206$ L atm/mol K; 8.3145 J/mol K

$B = -2.18 \times 10^{-18}$ J

1.0 kg = 2.2 lb

$N_A = 6.022 \times 10^{23}$

1.0 in = 2.54 cm

1 atm = 101,325 Pa = 1.01325 bar

1 lb = 453.59 g

1 J = 1 N • m = 1 kg • m^2 • s^{-2} = 0.239 cal

$c = 2.998 \times 10^8$ m/s

$h = 6.626 \times 10^{-34}$ J·s

Assume all gases behave ideally unless specifically told to do otherwise
Assume all solutions are aqueous and at 25 °C unless specifically told otherwise
Assume all gases are at STP unless specifically told otherwise

Simple Rules for the Solubility of Salts in Water

1. Most nitrates are soluble
2. Most salts containing Group 1 ions or ammonium (NH_4^+) are soluble
3. Most chloride, bromide, and iodide salts are soluble except those of Ag^+, Pb^{2+}, and Hg_2^{2+}.
4. Most sulfates are soluble with the exception of Ba^{2+}, Pb^{2+}, Hg_2^{2+}, and Ca^{2+}
5. Most hydroxide salts are only slightly soluble with the exception of Group 1 hydroxides. Group 2 (Ba^{2+} to Ca^{2+}) are slightly soluble.
6. Most sulfides, carbonates, chromates, and phosphates are only slightly soluble.

WYSE – Academic Challenge
Chemistry Test (State Final) – 2015

1. Which of the following solutions will have the highest concentration of chloride ions?

   A. 0.20 M LiCl
   B. 0.40 M $MgCl_2$
   C. 0.30 M $AlCl_3$
   D. 0.20 M $CaCl_2$
   E. All of these solutions have the same concentration of chloride ions.

2. What is the percent yield when 28.16 g of CO_2 are formed from the reaction of 8.000 moles of C_8H_{18} with 4.000 moles of O_2. The balanced chemical equation is:

   $$2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O$$

   A. 20.00% B. 25.00% C. 50.00% D. 12.50% E. 10.50%

3. The compound, $CH_3{-}C{\equiv}C{-}CH_3$, can be classified as an _____.

   A. alkene B. alkyne C. ether D. alkane E. amine

4. Carbon-14 (a radioactive isotope of carbon) decays according to first-order kinetics, and has a half-life of approximately 5,700 years. How long will it take a sample of ^{14}C atoms to decay until 25% of the original sample remains?

   A. 1,425 years B. 2,850 years C. 5,700 years D. 11,400 years E. 17,100 years

5. What are the permissible values for the angular quantum number (l) when n = 4?

   A. 1, 2, 3, 4 B. 0, 1, 2, 3 C. 1, 2, 3 D. 0, 1, 2 E. 1, 2

6. Use the data given to calculate the ΔH for the following reaction:

$$K(g) + Cl(g) \rightarrow K^+(g) + Cl^- (g)$$

1) $KCl(s) \rightarrow K^+(g) + Cl^-(g)$ ΔH= +718 kJ
2) $KCl(s) \rightarrow K(s) + 1/2\ Cl_2(g)$ ΔH= +436 kJ
3) $K(s) + 1/2\ Cl_2\ (g) \rightarrow K(g) + Cl(g)$ ΔH= +211 kJ

A. +71 kJ B. +1365 kJ C. –1365 kJ D. –71 kJ E. +56 kJ

7. A helium balloon at a high altitude has 2.1×10^4 L of helium at 0.40 atm and −13°C. If the balloon descends to an altitude where the atmospheric pressure is 1.0 atm and the temperature is 20 °C, what will the volume of the balloon be at the lower altitude?

A. 9.5×10^3 L
B. 8.0×10^3 L
C. 8.6×10^3 L
D. 1.3×10^4 L
E. 2.3×10^5 L

8. The following reaction produces ammonia with an equilibrium constant, K, of 0.65 at 375°C.

$$N_2(g) + 3\ H_2(g) \leftrightarrow 2\ NH_3(g)$$

Initial concentrations of H_2, N_2, and NH_3 are 0.76 M, 0.60 M and 0.48 M, respectively. Which of the following statements is correct?

A. The reaction will proceed from left to right.
B. The reaction will proceed from right to left.
C. Not enough information is available to make a prediction.
D. The reaction is already at equilibrium.
E. All of the above statements are correct.

9. The activation energy (E_a) of an uncatalyzed reaction is generally _____ a catalyzed reaction.

A. unrelated to
B. greater than
C. the same as
D. less than
E. none of these

10. If you use 12.0 mol of H_2 and 7.00 mol of O_2 to form H_2O, which is the limiting reagent and why?

    A. H_2, because you have 5 mol left over.
    B. O_2, because you use 6 mol O_2 with the 12 mol H_2.
    C. O_2, because you have 2 mol O_2 left over.
    D. O_2, because 7 mol O_2 is lower than 12 mol H_2 in number.
    E. H_2, because 2 mol H_2 are used for every mole of O_2, therefore all 12 mol H_2 will be used up.

11. NH_4SH, placed in a vessel at 22°C, decomposes to form NH_3 and H_2S.

    $$NH_4SH(s) \leftrightarrow NH_3(g) + H_2S(g)$$

    Calculate the equilibrium concentration of NH_3 and H_2S if 4 g of pure NH_4SH is placed in a closed vessel, given that $K = 1.2 \times 10^{-4}$ at 22°C.

    A. $[NH_3] = 1.1 \times 10^{-2}$ M, $[H_2S] = 0.60 \times 10^{-4}$ M
    B. $[NH_3] = [H_2S] = 0.60 \times 10^{-4}$ M
    C. $[NH_3] = [H_2S] = 2.2 \times 10^{-2}$ M
    D. $[NH_3] = [H_2S] = 1 .1 \times 10^{-2}$ M
    E. $[NH_3] = 0.60 \times 10^{-4}$ M, $[H_2S] = 1.1 \times 10^{-2}$ M

12. The atomic masses and abundances of four isotopes of a newly discovered element, utopiam, Up, are given below. What is the average atomic mass of Up?

Isotope	Mass, amu	%Abundance
Up-204	203.9730	1.400
Up-206	205.9744	24.10
Up-207	206.9759	22.10
Up-208	207.9766	52.40

    A. 205.3 amu B. 206.2 amu C. 207.2 amu D. 208.0 amu E. 204.0 amu

13. An aqueous solution of HBr can be categorized as a

    A. strong base.
    B. strong acid.
    C. weak acid.
    D. weak base.
    E. None of these.

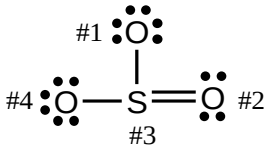
14. Which of the following hybridization involves bond angles of 120° and 180°?

A. sp B. sp^3d C. sp^2 D. sp^3 E. sp^3d^2

15. How many milliliters of a 0.104 M solution of $Ca(OH)_2$ will it take to titrate 7.34 mL of a 0.820 M solution of HBr?

A. 28.9 mL B. 537 mL C. 57.9 mL D. 116 mL E. 14.5 mL

16. What are the formal charges for each atom in this resonance structure for sulfur trioxide? The values are in the order from the atoms marked starting with #1 and ending with #4.



A. −1, 0, +2, −1
B. −1, −1, +2, 0
C. −1, 0, −1, +2
D. −1, −1, −1, −1
E. −1, −1, +1, +1

17. For the reaction: $2\ SO_3(g) \leftrightarrow 2\ SO_2(g) + O_2(g)$ you are given the following information.

ΔG^o_f for $SO_2(g)$ = –300.2 kJ/mol
ΔG^o_f for $SO_3(g)$ = –371.1 kJ/mol

Determine the value of ΔG^o for this reaction and state whether the forward reaction is spontaneous, nonspontaneous, or at equilibrium.

A. ΔG^o = 141.8 kJ. The forward reaction is nonspontaneous.
B. ΔG^o = 141.8 kJ. The reaction is at equilibrium.
C. ΔG^o = 141.8 kJ. The forward reaction is spontaneous.
D. ΔG^o = 70.9 kJ. The forward reaction is nonspontaneous.
E. ΔG^o = –70.9 kJ. The forward reaction is spontaneous.

18. What is the equilibrium expression for the following reaction?

$$Al^{3+}(aq) + H_2O(l) \leftrightarrow H^+(aq) + AlOH^{2+}(aq)$$

A. $K = [AlOH^{2+}]/[Al^{3+}]$
B. $K = [H^+][AlOH^{2+}]/[Al^{3+}]$
C. $K = [AlOH^{2+}]/[Al^{3+}][H_2O]$
D. $K = [H^+][AlOH^{2+}]/[Al^{3+}][H_2O]$
E. $K = [Al^{3+}][H_2O]/[H^+][AlOH^{2+}]$

19. Which of the following represents the net ionic equation of the combination of aqueous solutions of aluminum hydroxide and hydrobromic acid?

A. $Al(OH)_3(aq) + 3\ HBr(aq) \rightarrow AlBr_3(aq) + 3\ H_2O(l)$
B. $Al(OH)_3(aq) + 3\ H^+(aq) \rightarrow AlBr_3(aq) + 3\ H_2O(l)$
C. $Al^{3+}(aq) + 3\ Br^-(aq) \rightarrow AlBr_3(s)$
D. $Al(OH)_3(aq) + 3\ H^+(aq) \rightarrow Al^{3+}(aq) + 3\ H_2O(l)$
E. $3\ OH^-(aq) + 3\ H^+(aq) \rightarrow 3\ H_2O(l)$

20. Stannous ion is Sn^{2+}. What is **true** about the stannic ion?

A. It will have a greater charge than the stannous ion.
B. It will have a lesser charge than the stannous ion.
C. It will contain a hydrogen atom.
D. It will contain an oxygen atom.
E. All of the above are true.

21. Calcium chloride, $CaCl_2$, is sometimes used as a road de-icer. The solubility of $CaCl_2$ in cold water is 74.50 g per kilogram of water. Determine the lowest temperature for which $CaCl_2$ would be effective (k_f for water is 1.86 $^oC/m$). Assume Van't Hoff factor to be 3.0.

A. −1.30 ^{o}C B. 0 ^{o}C C. –3.75°C D. −1.85 ^{o}C E. 1.85 ^{o}C

22. Which of the following is a suffix used when naming cations?

A. –ite B. –ide C. –eum D. –ate E. –ium

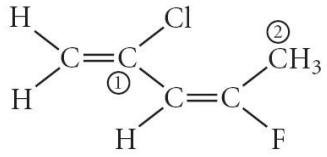
23. Which of the following is a correct statement of Hund's Rule?

A. No two electrons may share the same set of quantum numbers.
B. The location and the momentum of an electron cannot be known simultaneously.
C. Electrons will occupy separate degenerate orbitals and maintain parallel spins before pairing up.
D. Electrons in orbits further from the nucleus experience a lesser degree of nuclear charge.
E. Electrons will begin filling the lowest energy orbitals first.

24. Two gas tanks, at the same temperature, are connected by a valve. One tank contains 15 L of nitrogen at 7.2 atm of pressure and the other tank contains 8.3 L of helium at 4.1 atm of pressure. If the connecting valve is opened, what is the final pressure of the two tanks combined?

A. 0.48 atm B. 142 atm C. 6.1 atm D. 4.5 atm E. 23 atm

25. Consider the molecule below. What are the electron domain geometry names at each of the two labeled carbon atoms?



A. C1 = tetrahedral, C2 = linear
B. C1 = trigonal planar, C2= bent
C. C1 = bent, C2 = trigonal planar
D. C1 = trigonal planar, C2 = tetrahedral
E. C1 = trigonal pyramidal, C2 = see-saw

26. If 30 g of potassium iodide, KI, is dissolved in 250 g of water, what is the molality (mol solute per kg solvent) of this solution?

A. 0.045 *m* B. 0.72 *m* C. 0.12 *m* D. 0.65 *m* E. 0.36 *m*

27. For the reaction, $S_2O_8^{2-}(aq) + 3I^-(aq) \rightarrow 2SO_4^{2-}(aq) + I_3^-$, which of the following rates of changes of concentrations is **not** correct?

A. $\frac{1}{2}\frac{\Delta[SO_4^{2-}]}{\Delta t} = -\frac{1}{3}\frac{\Delta[I^-]}{\Delta t}$

B. $\frac{\Delta[I_3^-]}{\Delta t} = -\frac{3\Delta[I^-]}{\Delta t}$

C. $\frac{1}{2}\frac{\Delta[SO_4^{2-}]}{\Delta t} = \frac{\Delta[I_3^-]}{\Delta t}$

D. $-\frac{1}{3}\frac{\Delta[I^-]}{\Delta t} = -\frac{\Delta[S_2O_8^{2-}]}{\Delta t}$

E. $\frac{1}{2}\frac{\Delta[SO_4^{2-}]}{\Delta t} = -\frac{\Delta[S_2O_8^{2-}]}{\Delta t}$

28. What is the pH of pure water at 40.0°C if the K_W at this temperature is 2.92×10^{-14}?

A. 6.767 B. 0.465 C. 7.000 D. 7.233 E. 8.446

29. Which of the following has only one lone (nonbonding) pair of electrons on the central atom?

A. IF_5 B. $AsBr_5$ C. XeF_4 D. I_3^- E. CH_4

30. What is $[OH^-]$ for a solution with pH of 10.57?

A. 5.89×10^{-12} M
B. 1.58×10^{-3} M
C. 2.69×10^{-11} M
D. 3.16×10^{-4} M
E. 3.72×10^{-4} M

31. A saturated solution is _____

A. an immiscible mixture of solute and solvent.
B. a solution that has too much solute for a given temperature.
C. a mixture in which there is more solute than solvent.
D. a solution in which the solvent has dissolved the maximum amount possible of a given solute at a given temperature.
E. none of the above describes a saturated solution.

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

A. In both solids and liquids, the atoms or molecules pack closely to one another.
B. Solids are highly compressible.
C. Gaseous substances have long-range repeating order.
D. There is only one type of geometric arrangement that the atoms or molecules in any solid can adopt.
E. Liquids have a large portion of empty volume between molecules.

33. Identify the characteristics of a spontaneous reaction.

A. $\Delta G^\circ < 0$
B. $\Delta E^\circ_{cell} > 0$
C. $K > 1$
D. all of the above
E. none of the above

34. Which of the following occurs as the wavelength of a photon increases?

A. the speed decreases
B. the energy increases
C. the frequency decreases
D. Planck's constant decreases
E. the distance between adjacent peaks of the wave decreases

35. In the modern periodic table, which of the following is **true** for the trend in the first ionization energy?

	Along a period from left to right	Along a group from bottom to up
A.	Increases	Increases
B.	Increases	Decreases
C.	Decreases	Increases
D.	Decreases	Decreases
E.	No change	No change

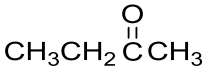
36. Which of the following represents a balanced chemical equation for the reaction between perchlorate ion and iodide ion in an **acidic** solution?

$$ClO_4^- + I^- \rightarrow Cl^- + I_2$$

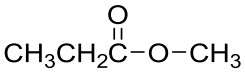
A. $ClO_4^- + 2\ I^- + 2\ H^+ \rightarrow Cl^- + I_2 + 2\ H_2O_2$
B. $ClO_4^- + 2\ I^- \rightarrow Cl^- + I_2 + 2\ O_2$
C. $ClO_4^- + 2\ I^- \rightarrow Cl^- + I_2$
D. $ClO_4^- + 8\ I^- + 8\ H^+ \rightarrow Cl^- + 4\ I_2 + 4\ H_2O$
E. $ClO_4^- + 2\ I^- \rightarrow Cl^- + 2\ I_2 + 2\ O_2$

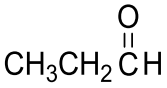
37. Which of the following compounds is a ketone?

A. $CH_3CH_2CH_2CO_2H$

B. 

C. $CH_3CH_2NH_2$

D. 

E. 

38. In nature the element oxygen exists as _____.

A. O B. O_2 C. O_3 D. O^{2-} E. O^-

39. The plastic Lucite™ is 71.4% carbon, 9.59% hydrogen, and 19.01% oxygen. What is the empirical formula of Lucite™?

A. C_5H_8O B. $C_{89}HO_{31}$ C. C_7HO_2 D. $C_{71}H_{10}O_{19}$ E. $C_6H_{10}O$

40. How many significant figures are there in the number 10.05060?

A. 3 B. 4 C. 5 D. 6 E. 7