2015 Academic Challenge

CHEMISTRY TEST – REGIONAL

This Test Consists of 40 Questions

Chemistry Test Production Team
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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	2A											3A	4A	5A	6A	7A	8A
1 H 1.008																	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 (Regional) – 2015

1. What is the implied uncertainty in a measurement that reads 534**.**32 mg?

   A. ± 10 mg B. ± 1 mg C. ± 100 mg D. ± 0.01 mg E. ± 0.001 mg

2. What is the coefficient for hydrochloric acid when calcium hydroxide reacts with hydrochloric acid to produce calcium chloride and water according to the reaction:

   $$Ca(OH)_2 + HCl \rightarrow CaCl_2 + H_2O$$

   A. 1 B. 2 C. 3 D. 4 E. 5

3. During an experiment, you measure the following lengths for an object: 4**.**23 m, 4**.**21 m, 4**.**23 m, 4**.**22 m. If the true length of the object is 5**.**02 mm which statement best describes your measurements?

   A. Your measurements are neither accurate nor precise.
   B. Your measurements are accurate and precise.
   C. Your measurements are not accurate but they are precise.
   D. Your measurements are accurate but not precise.
   E. All of the above.

4. How many significant figures should be recorded for the result of the calculation below?

   $$\frac{3.9 + 7.2}{0.3128}$$

   A. 5 B. 4 C. 3 D. 2 E. 1

5. The iron(III) ion, Fe^{3+}, will combine with the sulfate ion, SO_4^{2-}, to form an ionic compound. What is the expected chemical formula and name for this ionic compound?

   A. $FeSO_4$; Ferrous sulfate
   B. $FeSO_4$; Ferric sulfate
   C. $Fe_3(SO_4)_3$; Ferric sulfate
   D. $Fe_3(SO_4)_3$; Ferrous sulfate
   E. $Fe_2(SO_4)_3$; Ferric sulfate

6. Titanium will form the cation Ti^{4+}. What is the formula for the ionic compound titanium(IV) oxide, the white pigment in paint?

   A. TiO_4 B. Ti_2O C. Ti_4O_2 D.TiO E. TiO_2

7. A solution of K_2SO_4 and KCl is added to a solution of $Ba(NO_3)_2$. Which of these compounds will precipitate out of this combined solution?

   A. $BaCl_2(s)$ B. $BaSO_4(s)$ C. $KNO_3(s)$ D. $K_2S(s)$ E. $BaS(s)$

8. Using the balanced chemical equation shown, what mass of $FeCl_3$ will be produced from 6.00 moles of Cl_2?

$$2\ Fe(s) + 3\ Cl_2(g) \rightarrow 2\ FeCl_3(s)$$

A. 0.0250 g $FeCl_3$
B. 1,460 g $FeCl_3$
C. 649 g $FeCl_3$
D. 0.0550 g $FeCl_3$
E. 342 g $FeCl_3$

9. Hydronium (H_3O^+) is

A. a molecule.
B. a polyatomic anion.
C. a polyatomic cation.
D. an atom.
E. a gas.

10. Calcium carbonate reacts with hydrochloric acid to produce calcium chloride, water, and carbon dioxide. Which of the following balanced chemical equations represents this reaction?

A. $CaCO_3 \rightarrow CO + CO_2$
B. $CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$
C. $Ca(HO) + 2\ HCl \rightarrow CaCl_2 + 2\ H_2O$
D. $CaCO_3 + 2\ HCl \rightarrow CaCl_2 + H_2O + CO_2$
E. $CaCO_3 + HCl \rightarrow CaCl + 2\ H_2O + CO_2$

11. What mass of $AlCl_3$ can be formed from 5.00 mol $NiCl_2$ and 5.00 mol Al according to the following reaction?

$$2\ Al(s) + 3\ NiCl_2(aq) \rightarrow 2\ AlCl_3(aq) + 3\ Ni(s)$$

A. 534 g $AlCl_3$ B. 267 g $AlCl_3$ C. 222 g $AlCl_3$ D. 444 g $AlCl_3$ E. 701 g $AlCl_3$

12. In the following redox reaction which of the following statements correctly identifies the oxidizing agent and the reducing agent.

$$6\ Fe^{2+}(aq) + Cr_2O_7^{2-}(aq) + 14\ H^+(aq) \rightarrow 6\ Fe^{3+}(aq) + 2\ Cr^{3+}(aq) + 7\ H_2O(l)$$

A. H^+ is the oxidizing agent. Fe^{2+} is the reducing agent.
B. $Cr_2O_7^{2-}$ is the oxidizing agent. Fe^{2+} is the reducing agent.
C. $Cr_2O_7^{2-}$ is the oxidizing agent. Fe^{3+} is the reducing agent.
D. Fe^{2+} is the oxidizing agent. $Cr_2O_7^{2-}$ is the reducing agent.
E. Fe^{2+} is the oxidizing agent. H^+ is the reducing agent.

13. What is the concentration of chloride ion in the same volume of a solution that is 0.300 M NaCl and 0.200 M $MgCl_2$?

    A. 0.700 M B. 0.500 M C. 0.300 M D. 0.200 M E. 0.250 M

14. An unknown pesticide is made up of 18.28% carbon, 0.77% hydrogen, and 80.95% chlorine. What is the empirical formula of the pesticide?

    A. C_2HCl_8 B. CH_2Cl C. $C_3H_2Cl_2$ D. $C_8H_5Cl_3$ E. C_2HCl_3

15. With the discovery of isotopes, which postulate of Dalton's original atomic theory must be modified?

    A. Atoms of the same element are the same.
    B. In chemical reactions, the arrangement of atoms is changed.
    C. Atoms combine with other atoms in whole number ratios to form compounds.
    D. Matter is made up of atoms.
    E. Atoms are conserved in a chemical reaction.

16. _____are discrete packages of atoms connected together in well-defined numbers and ratios with no overall charge.

    A. Molecular ions
    B. Molecules
    C. Ionic compounds
    D. Covalent lattices
    E. None of the above

17. What is the difference between an experimental reading of 2 seconds and another reading (of the same event) of 2.0 seconds?

    A. The first reading (2 s) is more precise.
    B. The first reading (2 s) is more accurate.
    C. The second reading (2.0 s) is more precise.
    D. The measurements are exactly the same, because 2 = 2.0.
    E. You cannot discern a difference between the two measurements.

18. If 8.1 g of K_2SO_4 are dissolved in water to form 175 mL of solution, what is the molarity of potassium ions in the solution?

    A. 93 M B. 21 M C. 0.27 M D. 0.13 M E. 0.53 M

19. Methane can be decomposed into two simpler substances, hydrogen and carbon. Therefore, methane

    A. must have the formula CH.
    B. must be a mixture.
    C. is a gas.
    D. cannot be an element.
    E. is combustible.

20. PCl_5 dissociates to give PCl_3 and Cl_2 according to: $PCl_5(g) \leftrightarrow PCl_3(g) + Cl_2(g)$.

    The partial pressures of PCl_5, PCl_3, and Cl_2 at equilibrium are 0.875 atm, 0.463 atm, and 1.98 atm, respectively. The value of the equilibrium constant is _____.

    A. 1.05 B. 0.95 C. 3.74 D. 0.20 E. 2.50

21. Which of these is a chemical change?

    A. silkworms convert mulberry leaves into silk
    B. wool is spun into yarn
    C. the hair stylist cuts your hair
    D. bleaching powder dissolves in water
    E. none of the above

22. What is the pH of a solution if its $[OH^-]$ is 7.9×10^{-7} M?

    A. 9.98 B. 7.90 C. 12.82 D. 10.7 E. 7.00

23. Which statement about Q (the reaction quotient) and K (the equilibrium constant) is **not** correct?

    A. If Q < K, a shift toward the reactants is favored as the reaction moves to equilibrium.
    B. If Q > K, a shift toward the reactants is favored as the reaction moves to equilibrium.
    C. If Q << K, a shift toward the products is favored as the reaction moves to equilibrium.
    D. If Q = K, the reaction is at equilibrium.
    E. All of the above are correct.

24. Which of the following reactions would produce a salt that is acidic in solution? Consider the reactants are added in equimolar amount.

    A. HF + LiOH B. KOH + HCl C. $HNO_3 + NH_3$ D. HCl + NaOH E. KCl + NaCl

25. In an electromagnetic field alpha particles will _____ .

    A. be attracted to the positive pole of the field
    B. be attracted to the negative pole of the field
    C. be undeflected in the field
    D. be distributed evenly to both negative and positive poles
    E. carry some electrons of its own

26. Which of the following is **not** a general phase of pure substances?

    A. solid B. gas C. liquid D. solution E. none of these

27. Which of the following molecules has only one lone pair electron on the central atom?

    A. CH_4 B. SO_2 C. BCl_3 D. H_2S E. H_2O

28. In the following reaction, I^- is consumed at a rate of 2.5 $M.s^{-1}$. What is the rate of formation of I_2 in $M.s^{-1}$?

$$IO_3^- + 5\ I^- + 6\ H^+ \rightarrow 3\ I_2 + 3\ H_2O$$

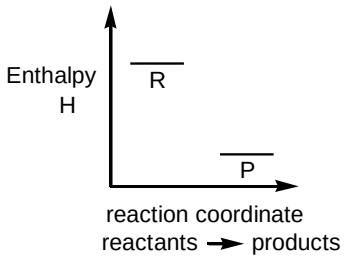
A. 4.2 B. 2.5 C. 1.5 D. 1.0 E. 0.25

29. What is the oxidation number for nitrogen in $Cu(NO_3)_2$ for the following reaction?

$$Cu(s) + 4\ HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2\ NO_2(g) + 2\ H_2O(l)$$

A. –5 B. –4 C. +4 D. +5 E. +7

30. What type of reaction is shown by this graph?



A. Exothermic
B. Endothermic
C. Dissolution
D. Precipitation
E. Gas evolution

31. Which of the following molecules has an odd number of valence electrons?

A. $[NH_4]^+$ B. NH_3 C. NO_2 D. N_2O E. CO_3^{2-}

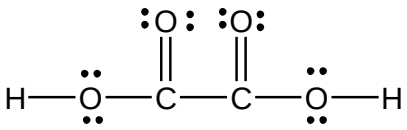
32. Determine the wavelength of light having an energy of 2.25 x 10^{-19} J.

A. 4.98 x 10^{-61} m
B. 1.13 x 10^{6} m
C. 1.02 x 10^{23} m
D. 1.02 x 10^{-23} m
E. 8.83 x 10^{-7} m

33. Which of the following chemical elements has properties that are most similar to selenium?

A. Arsenic B. Sulfur C. Phosphorus D. Bromine E. Chlorine

34. The Lewis dot structure for oxalic acid is shown in the drawing. Which statement about the bond angles for oxalic acid is **not** true?



A. The bond angles for the left half of the molecule are the same as those for the right half of the molecule.
B. Both O-C-O bond angles are 120°.
C. The O-C-C bond angles are 120°.
D. The H-O-C bond angles are 120°.
E. All of the above are incorrect.

35. Suppose you have a 2.5 L sample of gas at 132 °C. If the pressure does not change, what will the volume be at 35 °C?

A. 3.3 L B. 0.66 L C. 2.5 L D. 5.7 L E. 1.9 L

36. The final gas pressure in a stomp rocket is 2.75 times the initial pressure. What is the final volume of the gas if the initial volume is 2.73 L?

A. 0.993 L B. 2.73 L C. 7.51 L D. 22.3 L E. 5.50 L

37. A 2.32 L balloon contains helium at 1.00 atm and 25 °C. How many grams of helium are contained in the balloon?

A. 0.191 g He B. 4.52 g He C. 42.2 g He D. 0.379 g He E. 2.32 g He

38. As you move from the left to the right across the periodic table, which of the following is the correct trend?

A. Decreasing electron affinity
B. Increasing atomic radius
C. Increasing ionization energy
D. Decreasing atomic mass
E. Decreasing electronegativity

39. In which of the following ways is a 5s orbital likely to differ from a 1s orbital?

A. The maximum probability of finding an electron in a 5s orbital will be closer to the nucleus.
B. The probability of finding an electron in a 5s orbital will vary with the angular direction.
C. A 5s orbital will be able hold more than 2 electrons.
D. The electrons in a 5s orbital will have a lower energy.
E. The size of a 5s orbital will be greater.

40. What is the density of methane gas, CH_4, at STP?

A. 0.716 g/L B. 0.660 g/L C. 3.87 g/L D. 0.736 g/L E. 1.40 g/L