2016 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) – 2016

1. Which of the following species is a base?

   A. CH_4
   B. NH_3
   C. H_2CO_3
   D. CH_3COOH
   E. CH_3CH_3

2. The nitrate of an unknown cation is mixed with four different solutions. The results of these mixtures are shown below

	Solution	Result
1)	NaCl	No precipitate
2)	Na_2SO_4	Precipitate
3)	NaOH	No precipitate
4)	Na_2CO_3	Precipitate

   Based on the above results, which of the following is the most likely unknown cation?

   A. K^+ B. Na^+ C. Fe^{2+} D. Ag^+ E. Ca^{2+}

3. A sample of Ne gas is contained in a 265 mL flask at 0.0 °C at a pressure of 432 mm Hg. If the gas is transferred to a new flask at 25.0 °C, and its pressure is now 355 mm Hg, what is the volume of the new flask?

   A. 8060 mL B. 295 mL C. 238 mL D. 352 mL E. 1000 mL

4. When a gas expands, what is true about work, ***w***, according to thermodynamics?

   A. It is negative.
   B. It is positive.
   C. There is no change in sign.
   D. It becomes zero.
   E. This cannot be answered without further information.

5. A radio wave has a frequency of $2.10 \times 10^{6}\ s^{-1}$. What is its wavelength?

A. 6.30×10^{14} m
B. 1.43×10^{2} m
C. 7.00×10^{-3} m
D. 2.27×10^{-13} m
E. 1.43×10^{4} m

6. Which of the following has a linear geometry?

A. SO_2 B. H_2O C. CO_3^{2-} D. CO_2 E. CH_3Cl

7. Which of the following is the best description of intermolecular forces?

A. The forces between atoms in a molecule
B. The forces between the nucleus and an electron
C. The forces between different molecules of a substance
D. The forces valence shell electrons exert on each other
E. The forces between a proton and a neutron

8. Which compound is best described as ionic?

A. PCl_5 B. $CaSO_4$ C. C_5H_5N D. OF_2 E. ClBr

9. If a solute dissolves in a solvent, what is likely to be true?

A. The solute-solute attractions are greater than the solvent-solvent attractions
B. The solute-solute attractions are less than the solvent-solvent attractions
C. There is a strong attraction between solute and solvent molecules
D. The solute-solvent attraction is greater than the sum of the solute-solute and solvent-solvent
E. Answers B and C

10. A solution of 1.60 g of an unknown compound in 5.00 g of water has a freezing point of –5.98 °C. The solution does not conduct electricity. What is the molar mass of the compound? [The molal freezing-point constant for water is –1.86 °C/*m*.]

A. 45.0 g/mol
B. 5.98 g/mol
C. 99.4 g/mol
D. 47.8 g/mol
E. 123 g/mol

11. Correctly rounded, the sum of 2.7×10^{-3} mm and 1.5×10^{-4} mm is:

    A. 0.0028 m
    B. 0.002 m
    C. 0.003 m
    D. 0.00285 m
    E. 0.0029 m

12. What functional group best represents the following molecule?

    $$\mathbf{H_3C{-}O{-}CH_2CH_3}$$

    A. Alcohol B. Ether C. Ester D. Halide E. Amine

13. The identity of a monoatomic ion X^{2+} with 23 electrons and 27 neutrons.

    A. Na B. Al C. Mn D. Cu E. Ce

14. Given the following equilibrium:

    $$Cl_2(g) + Br_2(g) \rightleftarrows 2\ ClBr(g)$$

    and the equilibrium mixture containing 2.0×10^{-3} mol of Cl_2, 1.5×10^{-3} mol of Br_2, and 3.0×10^{-2} mol of ClBr in a 2.0 L container, what is the value of K_{eq}?

    A. 3.0×10^{2}
    B. 2.0×10^{4}
    C. $60. \times 10^{1}$
    D. 1.0×10^{-4}
    E. 3.3×10^{-2}

15. Which of the following represents the chemical species nitrite?

    A. HNO_3 B. NO_2^- C. NO_3^- D. N_3^- E. NO^-

16. The reaction xA + B → products is found to be second order in A. Which rate equation **cannot** be correct?

    A. Rate = $k[A]^2[B]$
    B. Rate = $k[A][B]^{½}$
    C. Rate = $k[A]^2$
    D. Rate = $k[A][B]$
    E. Answers B and D

17. What is the $[OH^-]$ of an acid with pH of 4.760?

    A. 9.67×10^{-1} M
    B. 6.78×10^{-1} M
    C. 1.74×10^{9} M
    D. 5.50×10^{-5} M
    E. 5.75×10^{-10} M

18. What is the coefficient for oxygen gas in the properly balanced equation for the combustion of propane and oxygen gas to form carbon dioxide gas and water according to the equation?

    $$C_3H_8 + O_2 \rightarrow CO_2 + H_2O$$

    A. 1 B. 2 C. 5 D. 10 E. 15

19. The volume of a certain gas sample is 1150 mL at a temperature of 298 K. At what temperature would the same gas sample have a volume of 1.53 L at constant pressure and mass?

    A. 248 °C B. 397 °C C. –49.1 °C D. 124 °C E. 2.5 °C

20. The three main types of radiations are alpha, beta, and gamma. Which of the following is correct about these radiations?

    A. Alpha radiation carries negative charge
    B. Beta radiation carries positive charge
    C. Gamma radiation carries negative charge
    D. Gamma radiation carries no charge
    E. Gamma radiation carries positive charge

21. What is the percentage of carbon in sucrose, $C_{12}H_{22}O_{11}$?

    A. 51.5% B. 6.4% C. 42.1% D. 30.1% E. 12%

22. Which of the following best defines ionization energy?

A. It is the energy required to add an electron to an atom.
B. It is the energy required to make both a cation and an anion.
C. It is the energy required to remove an electron from an atom.
D. It is the energy released when an ionic compound dissolves in water.
E. It is the energy needed when an ionic compound dissolves in water.

23. CH_4 has bond angles of _____ .

A. 90° B. 109.5° C. 120° D. 180° E. 360°

24. The name of the scientist who determined the ratio of mass of an electron to its electric charge was _____ .

A. Rutherford B. Thompson C. Dalton D. Bragg E. Lavoisier

25. Which of the following solutions would have $[Fe^{3+}] = 0.030$ M?

A. 0.30 L of 0.050 M $Fe_4(PO_4)_3$
B. 0.25 L of 0.040 M $Fe(NO_3)_3$
C. 0.40 L of 0.030 M Fe_2O_3
D. 0.40 L of 0.015 M $Fe_2(SO_4)_3$
E. 0.60 L of 0.020 M FeN_3

26. Which of the following is an example of a physical property of molecular oxygen (O_2)?

A. Less dense than Kr gas
B. Reacts with hydrogen
C. Converted to triatomic oxygen (O_3)
D. Separated from water by electrolysis
E. Answers A and D

27. What is the volume of a box with two sides measuring 1.4 meters and that of the third side 24 inches? [39.37 inch = 1.00 meter]

A. 1.2 meter^3 B. 2.7 meter^3 C. 0.003 meter^3 D. 34 inch^3 E. 47 inch^3

28. Which statement is true about isotopes of the same element?

    A. They have the same number of protons
    B. They have the same atomic weight
    C. They have the same number of neutrons
    D. They have a different atomic number
    E. Answers B and D

29. Which of the factors is **not** a condition necessary for equilibrium?

    A. A closed system
    B. Equal forward and reverse rates of reaction
    C. Constant temperature
    D. Equal concentrations of reactants and products
    E. Constant pressure

30. What is the name of the compound K_3PO_4?

    A. Potassium Phosphate
    B. Potassium Phosphide Oxide
    C. Potassium(I) Phosphate
    D. Tripotassium Phosphate
    E. Tripotassium Monophosphorous Tetroxide

31. In the energy profile of a reaction, the chemical species that exists at the maximum of the curve is called the _____.

    A. activation energy
    B. atomic state
    C. intermediate
    D. product
    E. activated complex

32. If you have 5.0 mol Mg_3N_2, and 6.0 mol H_2O, what amount of $Mg(OH)_2$ would be produced?

    $Mg_3N_2(aq) + 6\ H_2O(l) \rightarrow 3\ Mg(OH)_2(aq) + 2\ NH_3(g)$

    A. 15 mol $Mg(OH)_2$
    B. 3.0 mol $Mg(OH)_2$
    C. 2.0 g $Mg(OH)_2S$
    D. 15 g $Mg(OH)_2$
    E. 11 mol $Mg(OH)_2$

33. How does the kinetic molecular theory of gases explain the inverse relation between the volume and pressure of a gas? When the volume of a gas is reduced, _____.

A. gas molecules collide with the container more often, thus increasing the pressure
B. gas molecules experience greater intermolecular forces, thus decreasing the pressure
C. gas molecules increase in kinetic energy, thus increasing the pressure
D. gas molecules increase in temperature, thus increasing the pressure
E. none of these will happen

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

A. 1.43 g/L
B. 0.716 g/L
C. 0.795 g/L
D. 0.665 g/L
E. 3.55 g/L

35. Which one of the following compounds is a nonelectrolyte when dissolved in water?

A. Sugar
B. Sodium chloride
C. Calcium chloride
D. Copper Sulfate
E. Sodium bicarbonate

36. Which of the following hybridization involves bond angle values of 90º and 120°?

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

37. Which gas is both diatomic and colored?

A. carbon disulfide
B. oxygen
C. chlorine
D. argon
E. nitrous oxide

38. How many electrons, protons, and neutrons are in an atom of Cl-35?

A. 11-11-13
B. 35-17-17
C. 17-17-35
D. 17-35-70
E. 17-17-18

39. A solution of K_2SO_4 and KCl are added to a solution of $Ba(NO_3)_2$. Which compound will precipitate out of this combined solution?

A. KNO_3 B. K_2S C. $BaSO_4$ D.$BaCl_2$ E. H_2SO_4

40. What is the general formula for an alkaline earth metal halide?

A. MH B. MX C. M_2X D. MX_2 E. $M(OH)_2$