2017 Academic Challenge

CHEMISTRY TEST – SECTIONAL

– This Test Consists of 40 Questions –

Chemistry Test Production Team
Iffat Ali, Lake Land College – Author/Team Leader
Mary Konkle, Eastern Illinois University – Author
Gregory Capitosti, Lake Land College – Reviewer
Sahid L. Rosado Lausell, WYSE – Coordinator of Test Production

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 (Sectional) – 2017

1. For the nuclear symbol $^{19}_{9}\mathrm{F}$, the total number of subatomic particles in the fluorine atom is

   A. 9 B. 10 C. 18 D. 19 E. 28

2. A solution is 0.015 *M* each in LiCl, MgI_2, and $FeCl_3$. What is the molar concentration of chloride ions in this mixture?

   A. 0.045 *M* Cl^-
   B. 0.060 *M* Cl^-
   C. 0.030 *M* Cl^-
   D. 0.090 *M* Cl^-
   E. 0.135 *M* Cl^-

3. When a 1.50-g sample of a nonelectrolyte compound is dissolved in enough solvent to yield a 800.0-mL solution at 27.0 ºC, the osmotic pressure was recorded as 2.10 torr. What is the molar mass of this compound?

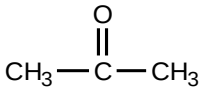
   A. 1.36×10^{-4} g/mol
   B. 16.7 g/mol
   C. 1.67×10^{4} g/mol
   D. 21.7 g/mol
   E. 9.10×10^{-5} g/mol

4. The energy required for the conversion of an ionic solid to widely separated gaseous ions is known as

   A. activation energy
   B. free energy
   C. ionization energy
   D. kinetic energy
   E. lattice energy

5. Consider two compounds A and B of equal mass. The density of A is greater than that of B. This means the volume of A _____ the volume of B.

   A. is less than
   B. is greater than
   C. is equal to
   D. cannot be compared to
   E. more information is needed to compare with

6. The organic compound shown is 

   A. an organic acid
   B. an alcohol
   C. an ether
   D. a ketone
   E. an aldehyde

7. Which of the following elements will have the greatest electronegativity?

   A. Si B. P C. N D. O E. C

8. Consider the following gas-phase equilibrium:

   $H_2(g) + I_2(g) \rightleftharpoons 2\ HI(g)$

   At a certain temperature, the equilibrium constant K_c is 4.0. A student started with an equimolar quantity of H_2 and I_2 and no HI. When equilibrium was established, he determined the HI amount to be of 0.20 mole. How many mole of H_2 was present at beginning?

   A. 0.10 mol
   B. 0.20 mol
   C. 0.30 mol
   D. 4.0 mol
   E. need to know the volume of the reaction vessel

9. What is the correct name for Li_2CO_3?

   A. lithium tricarbonate
   B. lithium carbonate
   C. lithium(II) carbonate
   D. dilithium carbon trioxide
   E. dilithium carbonate

10. Consider the following reaction in which nitric oxide is oxidized to nitrogen dioxide.

$$2\ NO(g) + O_2(g) \longrightarrow 2\ NO_2(g)$$

The rate law of this reaction is rate = $k[NO]^2[O_2]$.

If this reaction takes place in a sealed vessel and the total pressure were doubled by reducing the volume of the container by half, what effect would this have on the rate of reaction?

A. The reaction rate would double.
B. The reaction rate would triple.
C. The reaction rate would quadruple.
D. The reaction rate would increase by a factor of eight.
E. There would be no effect on the reaction rate.

11. Consider the combination of number and symbol in 5 N_2, which of the following is the most accurate?

A. 5 nitrogen atoms
B. 10 individual nitrogen atoms
C. 5 nitrogen molecules
D. 10 nitrogen molecules
E. none of these

12. Arrange the following in order of increasing concentration: 1% by mass, 1 ppb, 1 ppm, 1 ppt.

A. 1% < 1 ppm < 1 ppb < 1 ppt
B. 1 ppt < 1 ppb < 1 ppm < 1%
C. 1 ppt < 1 ppm < 1 ppb < 1%
D. 1 ppb < 1 ppm < 1 ppt < 1%
E. 1 ppm < 1 ppb < 1% < 1 ppt

13. In which of the following sequences of measured numbers do all members of the sequence contain three significant figures?

A. 3.03 and 3.30 and 0.033
B. 78,000 and 0.00780 and 780
C. 30.0 and 0.300 and 30,100
D. no correct response
E. all responses are correct

14. In the periodic table, as the atomic number increases from 11 to 17, what happens to the atomic radius?

    A. It remains constant
    B. It increases, then decreases
    C. It increases only
    D. It decreases, then increases
    E. It decreases only

15. The equilibrium concentrations found in the following reaction

    $$2\ A(g) + B(g) \rightleftharpoons C(g)$$

    are [A] = 2.4×10^{-2} *M*, [B] = 4.6×10^{-3} *M*, and [C] = 6.2×10^{-3} *M*. What is the value of K_c?

    A. 56
    B. 1.8×10^{-2}
    C. 4.3×10^{-4}
    D. 2.3×10^{3}
    E. 5.8×10^{2}

16. Which of the following is the correct name for the compound with formula Ca_3P_2?

    A. tricalcium diphosphorus
    B. calcium phosphite
    C. calcium phosphate
    D. calcium diphosphate
    E. calcium phosphide

17. Consider the hydrolysis of *t*-butyl chloride as represented by the following equation:

    $$(CH_3)_3CCl + H_2O \longrightarrow (CH_3)_3COH + HCl$$

    The rate expression of this reaction is: rate = $k[(CH_3)_3CCl]$. What is the order of the reaction with respect to each reactant, and what is the overall order?

    A. The order in *t*-butyl chloride is 1, the order in H_2O is 0, and the overall order is 1.
    B. The order in *t*-butyl chloride is 1, the order in H_2O is 1, and the overall order is 1.
    C. The order in *t*-butyl chloride is 0, the order in H_2O is 1, and the overall order is 1.
    D. The order in *t*-butyl chloride is 1, the order in H_2O is 1, and the overall order is 2.
    E. The order in *t*-butyl chloride is 1, the order in H_2O is 0, and the overall order is 2.

18. In a chemical reaction, when a species carries a positive charge, it has

    A. lost an electron.
    B. lost a proton.
    C. lost a neutron.
    D. gained an electron.
    E. gained a proton.

19. What is the mole fraction of sucrose ($C_{12}H_{22}O_{11}$) in a solution made by dissolving 325 g sucrose in 242 g H_2O?

    A. 0.0660 B. 3.92 C. 24.3 D. 0.0706 E. 0.573

20. The initial rate data in the table below represent the reaction

    $$2\ NO(g) + O_2(g) \longrightarrow 2\ NO_2(g)$$

    What is the experimental rate law for the reaction?

Experiment	Initial [NO], *M*	Initial [O_2], *M*	Initial rate of formation of NO_2,
1	0.10	0.10	$2.5 \times 10^{-4}\ M \cdot s^{-1}$
2	0.20	0.10	$5.0 \times 10^{-4}\ M \cdot s^{-1}$
3	0.20	0.40	$8.0 \times 10^{-3}\ M \cdot s^{-1}$

    A. rate = k [NO] [O_2]
    B. rate = k [NO] [O_2]^2
    C. rate = k [NO]^2 [O_2]
    D. rate = k [NO]^2 [O_2]^2
    E. rate = k [NO] / [O_2]

21. Which of the following acids is **not** a strong acid?

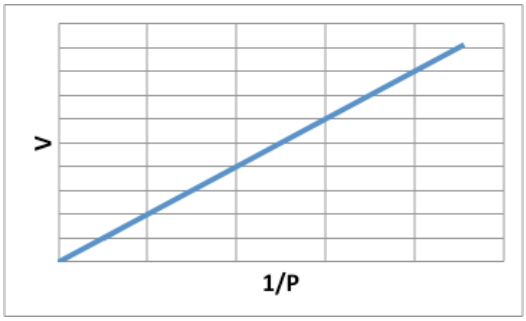
    A. HCl
    B. HBr
    C. HF
    D. HI
    E. all of the above are strong acids

22. Balance the chemical equation below and select the appropriate coefficients below.

___ $C_6H_5CH_3(l)$ + ___ $O_2(g)$ → ___ $CO_2(g)$ + ___ H_2O (l)

A. 1, , 8, 4, 6
B. 2, 8, 4, 6
C. 1, 9, 7, 4
D. 2, 9, 7, 4
E. Equation is balanced as written

23. The following graph illustrates which one of the gas laws?



A. Charles's Law
B. Combined Gas Law
C. General Gas Law
D. Boyle's Law
E. Ideal Gas Law

24. Calculate the energy that must be transferred from the surroundings to a 10.0 g sample of copper to raise the temperature of the copper from 298 K to 598 K. The specific heat of copper is 0.385 J/(g . K)

A. 1160 J B. –160 J C. –1160 J D. 1160 K E. 300 K

25. A beta particle is a particular type of a(n)

A. atom B. proton C. carbon D. electron E. none of these

26. What is the percent composition of hydrogen in ammonia?

A. 17.78% B. 12.86% C. 22.39% D. 82.21% E. 25.00%

27. What is the wavelength (in meters) of a cell phone signal operating at 1.12 GHz?

A. 2.68 m B. 0.268 m C. 268 m D. 0.0268 m E. 300 m

28. The change of zinc metal going to zinc ion is a(n)

A. oxidation
B. reduction
C. neutralization
D. electrolyzed
E. none of the above

29. A covalent compound that is tetrahedral in shape is

A. ammonia
B. carbon dioxide
C. sulfate ion
D. water
E. methane

30. Which of the following is **not** a Bronsted-Lowry acid?

A. BF_3
B. NH_4^+
C. $HC_2H_3O_2$
D. HCl
E. all of the above are Bronsted-Lowry acids

31. The unbalanced equation below is an example of a _____ reaction

$$C_6H_5CH_3(l) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$$

A. combination
B. decomposition
C. displacement
D. combustion
E. metathesis

32. Calculate the density of CO_2 at STP.

A. 1.00 g/L B. 5.00 g/L C. 1.96 g/L D. 0.960 g/L E. 0.100 g/L

33. Which of the following is/are state function(s) of thermodynamics?

A. enthalpy
B. entropy
C. pressure
D. volume
E. all of the above are state functions

34. What mass of carbon is contained in 454 g of propane, C_3H_8?

A. 300. g B. 81.7 g C. 18.2 g D. 371 g E. 454 g

35. The anode in an electrochemical cell is characterized by

A. being directly connected to the salt bridge
B. the location of the reduction
C. being the same as the cathode
D. marked by a positive sign
E. the location of the oxidation

36. Which molecule has the largest electronegativity difference along a bond?

A. O_2 B. CH_4 C. HF D. H_2O E. HCl

37. What type of molecular interaction is most relevant to a solution of saturated solution of sodium chloride?

A. induced dipole
B. dispersion
C. ion-dipole
D. dipole-dipole
E. pi stacking

38. Using the equation below, if you react 25.0 g of glucose ($C_6H_{12}O_6$) with 27.0 g of oxygen gas, what mass of water will you produce?

$C_6H_{12}O_6(s) + 6\ O_2(g) \rightarrow 6\ CO_2(g) + 6\ H_2O(l)$

A. 15.2 g of water
B. 15.0 g of water
C. 0.833 g of water
D. 25. 0 g of water
E. 13.0 g of water

39. What is the number of waves passing a given point per unit time?

A. wavelength
B. frequency
C. wavenumber
D. node
E. amplitude

40. The process by which molecules directly transition from a solid to gas phase is

A. evaporation
B. burning
C. condensation
D. freezing
E. sublimation