



2014 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. Only one oval should be marked to answer each question. Multiple ovals will automatically be graded as incorrect answers.

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!

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Periodic Table of the Elements

1A	2A	3A	4A	5A	6A	7A	8A
1 H 1.008	4 Be 9.012	5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	2 He 4.003
3 Li 6.941	12 Mg 24.31	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	10 Ne 20.18
11 Na 22.99	20 Ca 40.08	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	21 Sc 44.96	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	39 Y 88.91	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	57 La* 138.9	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	89 Ac** (227)	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96
		28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.92
		27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59
		26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72
		25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38
		24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55
		23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69
		22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93
		21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85
		20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94
		19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00
		18 Ar 39.95	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94
		17 Cl 35.45	18 Ar 39.95	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88
		16 S 32.07	17 Cl 35.45	18 Ar 39.95	19 K 39.10	20 Ca 40.08	21 Sc 44.96
		15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95	19 K 39.10	20 Ca 40.08
		14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95	19 K 39.10
		13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
		12 Mg 24.31	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45
		11 Na 22.99	12 Mg 24.31	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07
		10 Ne 20.18	11 Na 22.99	12 Mg 24.31	13 Al 26.98	14 Si 28.09	15 P 30.97
		9 F 19.00	10 Ne 20.18	11 Na 22.99	12 Mg 24.31	13 Al 26.98	14 Si 28.09
		8 O 16.00	9 F 19.00	10 Ne 20.18	11 Na 22.99	12 Mg 24.31	13 Al 26.98
		7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18	11 Na 22.99	12 Mg 24.31
		6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18	11 Na 22.99
		5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
		4 Be 9.012	5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00
		3 Li 6.941	4 Be 9.012	5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00
		2 He 4.003	3 Li 6.941	4 Be 9.012	5 B 10.81	6 C 12.01	7 N 14.01
		1 H 1.008	2 He 4.003	3 Li 6.941	4 Be 9.012	5 B 10.81	6 C 12.01

*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

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

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

$$P_{\text{solvent}} = X_{\text{solvent}} \cdot P_{\text{solvent}}^{\circ}$$

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

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

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

$$\text{pH} = -\log [\text{H}_3\text{O}^+]$$

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

$$\Delta G^{\circ} = \Delta H^{\circ} - T\Delta S^{\circ}$$

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

$$\Delta G^{\circ} = -nF\mathcal{E}^{\circ}$$

$$F = 96485 \text{ C/mol}$$

$$R = 0.08206 \text{ L atm/mol K}; 8.3145 \text{ J/mol K}$$

$$1.0 \text{ kg} = 2.2 \text{ lb}$$

$$1.0 \text{ in} = 2.54 \text{ cm}$$

$$1 \text{ lb} = 453.59 \text{ g}$$

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

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

$$S_{\text{gas}} = k_H \cdot P_{\text{gas}}$$

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

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

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

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

$$\text{pOH} = -\log [\text{OH}^-]$$

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

$$E_{\text{cell}}^{\circ} = E_{\text{red}}^{\circ} + E_{\text{ox}}^{\circ}$$

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

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

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

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

$$1 \text{ atm} = 101,325 \text{ Pa} = 1.01325 \text{ bar}$$

$$1 \text{ J} = 1 \text{ N} \cdot \text{m} = 1 \text{ kg} \cdot \text{m}^2 \cdot \text{s}^{-2} = 0.239 \text{ cal}$$

$$c = \lambda \nu$$

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) – 2014

1. What mass of phosphorus is present in 3.50 moles of P_4O_6 ?
 - A. 31.0 g
 - B. 108 g
 - C. 220. g
 - D. 434 g
 - E. 770. g
2. A mixture of oxygen and nitrogen has a total pressure of 1.50 atm. If the partial pressure of oxygen is 0.875 atm, what is the partial pressure of nitrogen in the mixture?
 - A. 0.63 atm
 - B. 0.750 atm
 - C. 0.875 atm
 - D. 1.50 atm
 - E. 2.38 atm
3. A V-shaped molecule with a tetrahedral electron arrangement around the central atom should have how many lone pairs on the central atom?
 - A. 0
 - B. 1
 - C. 2
 - D. 3
 - E. 4
4. If 0.750 L of solution contains 0.400 g of NaCl, calculate the concentration of this solution.
 - A. 5.13×10^{-3} M
 - B. 6.84×10^{-3} M
 - C. 9.13×10^{-3} M
 - D. 0.533 M
 - E. 17.5 M
5. Predict the molecular shape of ICl_3 .
 - A. T-shaped
 - B. V-shaped
 - C. Trigonal bipyramid
 - D. Trigonal planar
 - E. Tetrahedral
6. Given the exothermic reaction below, what conditions would favor the formation of ammonia?
$$N_{2(g)} + 3H_{2(g)} \leftrightarrow 2NH_{3(g)}$$
 - A. High pressure, high temperature
 - B. Low pressure, high temperature
 - C. High pressure, low temperature
 - D. Low pressure, low temperature
 - E. Low pressure, unaffected by temperature

7. What is the answer to the problem below, reported to the correct number of significant figures?

$$\frac{3.927 + 6.1}{1.792}$$

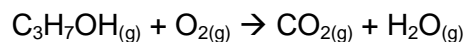
- A. 6 B. 5.6 C. 5.60 D. 5.595 E. 5.5954
8. How many moles of chlorine gas does it take to fill a 2.4 L vessel at a temperature of 20.0 °C and a pressure of 1.3 atm?

- A. 0.065 mol
B. 0.13 mol
C. 0.95 mol
D. 1.0 mol
E. 1.9 mol

9. What is the most electronegative element listed below?

- A. As B. Si C. Ga D. P E. Ge

10. When the reaction below is balanced with the smallest, whole-number coefficients, what is the coefficient on oxygen?



- A. 1
B. 2.5
C. 4.5
D. 5
E. 9
11. What mass of NaOH is needed to prepare 150.0 mL of a 0.185 M solution?
- A. 0.0278 g
B. 1.11 g
C. 1.50 g
D. 4.4 g
E. 40.0 g

12. Which molecule below contains the greatest number of π -bonds?

- A. O₂ B. F₂ C. SO D. N₂ E. CH₂O

13. What is the molecular mass of B_2H_6 ?

- A. 1.008 g/mol
- B. 10.81 g/mol
- C. 11.82 g/mol
- D. 13.83 g/mol
- E. 27.67 g/mol

14. Which of the following represents the largest amount of mass?

- A. 1.00×10^{-5} kg
- B. 0.0100 g
- C. 1.00×10^4 μ g
- D. 1.00 cg
- E. 100 mg

15. How many of the following are named correctly?

Compound	Name
MgO	Manganese(II) oxide
SiO ₂	Silicon dioxide
NaNO ₂	Sodium nitrite
N ₂ O ₄	Nitrogen(II) tetroxide

- A. 0 (none are named correctly)
- B. 1
- C. 2
- D. 3
- E. 4 (all are named correctly)

16. What is the formula of iron(III) sulfide?

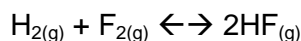
- A. Fe₃S
- B. FeS₃
- C. FeS
- D. Fe₃S₂
- E. Fe₂S₃

17. The mass of an atom is due primarily to _____; the volume of an atom is due primarily to _____, respectively.

- A. Protons; neutrons and electrons
- B. Protons and electrons; neutrons
- C. Electrons; protons and neutrons
- D. Protons and neutrons; electrons
- E. Neutrons; protons and electrons

18. Which of the following lists the proper charge for each subatomic particle?
- A. Proton = -1; Neutron = 0; Electron = +1
 - B. Proton = +1; Neutron = -1; Electron = 0
 - C. Proton = 0; Neutron = +1; Electron = -1
 - D. Proton = -1; Neutron = +1; Electron = 0
 - E. Proton = +1; Neutron = 0; Electron = -1
19. In nuclear chemistry, α -decay involves a nucleus emitting a particle made up of two neutrons and two protons, leaving the rest of the nucleus behind. If an atom of uranium (U) undergoes α -decay, what element will be produced?
- A. Cm B. Pu C. U D. Th E. Ra
20. In an oxidation/reduction reaction, the role of a reducing agent is to:
- A. Provide electrons to the oxidizing agent.
 - B. Act as a spectator species.
 - C. Serve as a passive cathode.
 - D. Accept electrons from the oxidizing agent.
 - E. Serve as an active cathode.
21. Which species below has the largest radius?
- A. Se^{2-} B. Br^- C. Kr D. Rb^+ E. Cl^-
22. Given the balanced reaction below, how many moles of NaOH are required to completely react with 25.0 g of CO_2 ?
- $$\text{CO}_{2(\text{g})} + 2\text{NaOH}_{(\text{aq})} \rightarrow \text{Na}_2\text{CO}_{3(\text{aq})} + \text{H}_2\text{O}_{(\text{l})}$$
- A. 0.284 mol B. 0.568 mol C. 1.14 mol D. 50.0 mol E. 66.5 mol
23. Which of the following samples contains the **greatest** number of chlorine atoms?
- A. 0.100 mol PbCl_4
 - B. 0.150 mol CHCl_3
 - C. 0.200 mol Cl_2
 - D. 0.250 mol CHF_2Cl
 - E. 0.300 mol $\text{C}_2\text{H}_7\text{Cl}$

24. The mass percents of hydrogen in samples of caffeine from two different sources are identical. This is an illustration of what fundamental law of chemistry?
- A. The law of definite composition.
 - B. The law of conservation of mass.
 - C. The law of multiple proportions.
 - D. Avogadro's law.
 - E. Dalton's law.
25. For the reaction below at equilibrium, $P_{\text{H}_2} = 0.500$ atm, $P_{\text{F}_2} = 0.300$ atm, and $P_{\text{HF}} = 2.50$ atm. What is the value of K_p for this reaction?



- A. 0.375
 - B. 10.4
 - C. 16.7
 - D. 33.3
 - E. 41.7
26. Which species below contains both ionic and covalent bonds?
- A. BaCl_2
 - B. NaNO_2
 - C. HF
 - D. CO_3^{2-}
 - E. TiCl_4
27. A gas sample in a 4.30 L container has a pressure of 648 torr. If the volume of the container is expanded to 6.00 L at constant temperature, what is the new pressure of the gas?
- A. 0.611 torr
 - B. 432 torr
 - C. 464 torr
 - D. 648 torr
 - E. 904 torr
28. Which reaction below shows the properly balanced reaction between sulfur trioxide and carbon to form sulfur dioxide and carbon dioxide?
- A. $2\text{SO}_{3(g)} + \text{C}_{(s)} \rightarrow 2\text{SO}_{2(g)} + \text{CO}_{2(g)}$
 - B. $\text{SO}_{3(g)} + \text{C}_{(s)} \rightarrow \text{SO}_{2(g)} + \text{CO}_{2(g)}$
 - C. $2\text{SO}_{3(g)} + \text{C}_{(s)} \rightarrow \text{S}_2\text{O}_{4(g)} + \text{CO}_{2(g)}$
 - D. $\text{SO}_{3(g)} + \text{C}_{(s)} \rightarrow \text{SO}_{2(g)} + \text{CO}_{(g)}$
 - E. $\text{S}_{(g)} + 2\text{O}_{2(g)} + \text{C}_{(s)} \rightarrow \text{SO}_{2(g)} + \text{CO}_{2(g)}$

29. Which of the following reactions is labeled **incorrectly**?

- A. $2\text{C}_2\text{H}_6(\text{g}) + 7\text{O}_2(\text{g}) \rightarrow 4\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{g})$ Combustion reaction
 B. $\text{CaO}(\text{s}) + \text{CO}_2(\text{g}) \rightarrow \text{CaCO}_3(\text{s})$ Decomposition reaction
 C. $\text{Mg}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) \rightarrow \text{Mg}(\text{OH})_2(\text{s})$ Precipitation reaction
 D. $\text{H}_2\text{SO}_4(\text{aq}) + \text{Ba}(\text{OH})_2(\text{aq}) \rightarrow \text{BaSO}_4(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$ Acid/base reaction
 E. All of the above equations are labeled correctly.

30. Which of the aqueous solutions below would have the **lowest** freezing point? Assume all solutions are ideal.

- A. 0.25 m CaCl_2
 B. 0.25 m sucrose ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$)
 C. 0.25 m glucose ($\text{C}_6\text{H}_{12}\text{O}_6$)
 D. 0.25 m NaCl
 E. All of the above solutions will have the same freezing point

31. Which of the following has the greatest number of unpaired electrons in its ground-state configuration?

- A. P B. Sc C. Ca D. F E. B

32. When a reaction absorbs heat, it is considered to be:

- A. Exergonic
 B. Exothermic
 C. Endergonic
 D. Endothermic
 E. Impossible to determine

33. The balanced reaction between compounds A and B is given below. If 20.0 g of compound A completely reacts with 16.0 g of compound B, with no excess of either reactant left over, what mass of compound C is produced?



- A. 16.0 g B. 20.0 g C. 24.0 g D. 36.0 g E. 60.0 g

34. Which of the following is a chemical property?

- A. Silver utensils tarnish over time.
 B. Water boils at 100.0 °C.
 C. Dry ice sublimates at room temperature.
 D. A block of wood weighs 1.25 lbs.
 E. A Granny Smith apple is green.

35. Which of the following is **not** a valid set of quantum numbers for an electron in a ground state chromium (Cr) atom?
- A. (1,0,0,+ ½)
 - B. (2,1,0,- ½)
 - C. (3,2,1,+ ½)
 - D. (4,0,0,- ½)
 - E. (4,1,-1,+ ½)
36. An 85.0 mL weak monoprotic acid solution is titrated by 0.270 M KOH. It takes 39.85 mL of the titrant to reach the equivalence point. What is the concentration of the weak acid solution?
- A. 0.0862 M
 - B. 0.108 M
 - C. 0.127 M
 - D. .270 M
 - E. 10.8 M
37. If a reaction is second order in compound A, third order in compound B, and zero order in all other species, what is the overall reaction order?
- A. 2
 - B. 2.5
 - C. 3
 - D. 4
 - E. 5
38. What volume will 0.350 moles of fluorine gas occupy at STP?
- A. 0.350 L
 - B. 7.84 L
 - C. 8.44 L
 - D. 22.4 L
 - E. 24.1 L
39. Balance the reaction below.
- $$\text{Al}_{(s)} + \text{Cl}_{2(g)} \rightarrow \text{AlCl}_{3(s)}$$
- A. $\text{Al}_{(s)} + \text{Cl}_{2(g)} + \text{Cl}_{(g)} \rightarrow \text{AlCl}_{3(s)}$
 - B. $2\text{Al}_{(s)} + 3\text{Cl}_{2(g)} \rightarrow 2\text{AlCl}_{3(s)}$
 - C. $\text{Al}_{(s)} + \text{Cl}_{2(g)} \rightarrow \text{AlCl}_{2(s)}$
 - D. $\text{Al}_{(s)} + 3\text{Cl}_{(g)} \rightarrow \text{AlCl}_{3(s)}$
 - E. $\text{Al}_{(s)} + \text{Cl}_{2(g)} \rightarrow \text{AlCl}_{3(s)}$
40. How many milliliters of 0.594 M NaOH are required to completely react with 25.00 mL of 0.350 M H₂SO₄?
- A. 7.37 mL
 - B. 8.75 mL
 - C. 14.8 mL
 - D. 25.0 mL
 - E. 29.5 mL