

SOME THINGS TO NOTE ABOUT THE TEST:

As this is meant for practice on using the Scilympiad platform to take tests, I intentionally made the test a bit shorter than you might usually expect so that hopefully you can take a look at all of the questions, as I tried to use all the different question-type options that Scilympiad provides.

Although I can properly write scientific notation and chemical formulas in the questions, I cannot do that in the answer options for multiple choice. Therefore, if I were to write 5×10^{-2} as an answer option, it would look something like 5×10^{-2} . Similarly, chemical formulas like H_2O would look something like H2O .

Lastly, and most importantly, **please pay attention to significant figures when solving calculation problems.**

Provided is a picture of the periodic table with molar masses (I apologize about the blurriness, if you have problems seeing the values please message me in the chat and I will provide them to you).

Periodic Table of the Elements

1 H 1.01																	18 He 4.00																														
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 18.00	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 32.06	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 51.99	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.09	35 Br 79.90	36 Kr 84.00																														
37 Rb 84.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc 98.91	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.6	53 I 126.90	54 Xe 131.29																														
55 Cs 132.91	56 Ba 137.33	57-103 Lanthanides	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.20	83 Bi 208.98	84 Po [209]	85 At [209]	86 Rn 222.02																														
87 Fr 223.02	88 Ra 226.03	89-103 Actinides	104 Rf [261]	105 Db [262]	106 Sg [266]	107 Bh [264]	108 Hs [269]	109 Mt [268]	110 Ds [289]	111 Rg [272]	112 Cn [277]	113 Uut unknown	114 Fl [289]	115 Uup unknown	116 Lv [290]	117 Uus unknown	118 Uuo unknown																														
<table border="1"> <tr> <td>57 La 138.91</td> <td>58 Ce 140.12</td> <td>59 Pr 140.91</td> <td>60 Nd 144.24</td> <td>61 Pm 144.91</td> <td>62 Sm 150.36</td> <td>63 Eu 151.97</td> <td>64 Gd 157.25</td> <td>65 Tb 158.93</td> <td>66 Dy 162.50</td> <td>67 Ho 164.93</td> <td>68 Er 167.26</td> <td>69 Tm 168.93</td> <td>70 Yb 173.04</td> <td>71 Lu 174.97</td> </tr> <tr> <td>89 Ac 227.03</td> <td>90 Th 232.04</td> <td>91 Pa 231.04</td> <td>92 U 238.03</td> <td>93 Np 237.05</td> <td>94 Pu 244.06</td> <td>95 Am 243.06</td> <td>96 Cm 247.07</td> <td>97 Bk 247.07</td> <td>98 Cf 251.08</td> <td>99 Es [254]</td> <td>100 Fm 257.10</td> <td>101 Md 258.10</td> <td>102 No 259.10</td> <td>103 Lr [262]</td> </tr> </table>																		57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm 144.91	62 Sm 150.36	63 Eu 151.97	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97	89 Ac 227.03	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu 244.06	95 Am 243.06	96 Cm 247.07	97 Bk 247.07	98 Cf 251.08	99 Es [254]	100 Fm 257.10	101 Md 258.10	102 No 259.10	103 Lr [262]
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Alkali Metal Alkaline Earth Transition Metal Basic Metal Semimetal Nonmetal Halogen Noble Gas Lanthanide Actinide

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Feel free to type in the chat if you have any more questions, and good luck!

1. (1.00 pts) How could one prepare 1.000 kg of 4.3% by mass KCl(aq) ?

- A) By dissolving 43.0 g KCl in 1000.0 g of water
- B) By dissolving 43 g KCl in 957 g of water
- C) By dissolving 4.3 g KCl in 1000.0 g of water
- D) By dissolving 4.3 g KCl in 995.7 g of water
- E) By dissolving 995.7 g KCl in 4.3 g of water

2. (1.00 pts)

26.7 g of an unknown substance was diluted with water in a 1.000 L volumetric flask. The molarity of the solution was determined to be 0.345 M. What is the molar mass of the unknown substance?

- A) 0.0129 g/mol
- B) 9.21 g/mol
- C) 26.4 g/mol

D) 77.4 g/mol

3. (1.00 pts) What is the molality of an aqueous solution that is 10.0% ethanol, C_2H_5OH , by mass?

- A) 1.38 m
 B) 1.77 m
 C) 2.17 m
 D) 2.42 m
 E) 2.66 m

4. (1.00 pts) If the concentration of KCl in water is 113 ppm, what is the molarity of this solution? Assume the density of the solution is 1.00 g/mol.

- A) 0.660 M
 B) 8.42×10^{-3} M
 C) 1.52×10^{-3} M
 D) 1.19×10^{-4} M
 E) 1.52×10^{-9} M

5. (1.00 pts) What is the mole fraction of methanol, CH_3OH , in an aqueous solution that is 20.0% methanol by mass?

- A) 0.101
 B) 0.123
 C) 0.250
 D) 0.308
 E) 0.544

6. (1.00 pts) Which aqueous solution would have the highest vapor pressure at 25°C?

- A) 1 M LiCl
 B) 1 M Na_2CO_3
 C) 1 M $C_6H_{12}O_6$
 D) 1 M NaOH

7. (1.00 pts) The concentration of H^+ in hydrochloric acid is reduced to 12% of its initial value by dilution. What is the difference in the pH values of the two solutions?

- A) 0.08
 B) 0.12
 C) 0.88
 D) 0.92

8. (1.00 pts) What is the molarity of OH^- in a solution with 0.020 M H_3O^+ ?

- A) $5.0 \times 10^{-6} \text{ M}$
- B) $5.0 \times 10^{-13} \text{ M}$
- C) 0.080 M
- D) 0.020 M

9. (1.00 pts) What is the pH and pOH of a 0.0146 M solution of $\text{HNO}_3(\text{aq})$?

- A) pH = 0.0146; pOH = 0.9854
- B) pH = 0.9854; pOH = 0.0146
- C) pH = 1.84; pOH = 12.16
- D) pH = 12.16; pOH = 1.84

10. (1.00 pts) What is the molarity of H_3O^+ ions in a beer with pH of 4.4?

- A) $5 \times 10^{-4} \text{ M}$
- B) $2 \times 10^{-7} \text{ M}$
- C) $4 \times 10^{-5} \text{ M}$
- D) $5 \times 10^{-6} \text{ M}$

11. (1.00 pts) What is the K_a value of phosphoric acid, which has $\text{p}K_{a1} = 2.12$?

- A) 7.6×10^{-3}
- B) 1.0×10^{-2}
- C) 3.5×10^{-3}
- D) 1.2×10^{-2}

12. (1.00 pts) What is the pH of the solution resulting when 5.00 mL of 0.150 M $\text{NaOH}(\text{aq})$ is added to 25.00 mL of 0.100 M $\text{HCOOH}(\text{aq})$? Use $K_a = 1.8 \times 10^{-4}$ for HCOOH .

- A) 2.37
- B) 3.38
- C) 4.20
- D) 7.50

13. (1.00 pts) What is the volume of 0.150 M $\text{HCl}(\text{aq})$ required to neutralize all the hydroxide ions in 25.0 mL of 0.110 M $\text{NaOH}(\text{aq})$?

- A) 0.00917 L
- B) 0.0635 L
- C) 0.0225 L
- D) 0.0183 L

14. (1.00 pts) What is the pH of a buffer solution of 0.040 M NaCH_3CO_2 and 0.080 M CH_3COOH at 25°C? The $\text{p}K_a$ of acetic acid is 4.75.

- A) 2.92
- B) 4.44
- C) 9.56
- D) 11.08

15. (1.00 pts) If 1.2 g of NaOH was dissolved in 500. mL of the buffer solution in the previous question, what would the resulting pH be?

- A) 4.44
- B) 5.44
- C) 8.56
- D) 9.56

16. (1.00 pts) If you titrate 25.00 mL of 0.250 M NaOH with 5.00 mL of 0.340 M HCl, what is the resulting pH?

- A) 0.82
- B) 4.55
- C) 6.25
- D) 13.18

17. (1.00 pts) What is the pH at the stoichiometric point of the titration of 25.00 mL of 0.100 M HCOOH with 0.150 M NaOH? $K_a = 1.8 \times 10^{-4}$ for formic acid.

- A) 1.8
- B) 4.2
- C) 5.7
- D) 8.3

18. (1.00 pts)

At 25°C, 100 g of water will be saturated with 35.7 g of NaCl. 1.55 mol of NaCl is dissolved in 250 mL of water. Which of the following choices best describes this solution?

- A) Unsaturated
- B) Saturated
- C) Supersaturated
- D) Metasaturated

19. (1.00 pts) Calculate the freezing point of a solution that contains 8.0 g of sucrose, $C_{12}H_{22}O_{11}$, in 100. g of H_2O , given that the K_f for water is $1.86^\circ C/m$.

- A) -0.044 degrees C
- B) -0.22 degrees C
- C) -0.39 degrees C
- D) -0.44 degrees C
- E) 0.044 degrees C

20. (1.00 pts) If the van't Hoff factor for NaCl is 1.88, what is the freezing point of a 0.50 m NaCl solution in water? $K_f = 1.86^\circ C/m$ for water.

- A) -1.86 degrees C
- B) -1.75 degrees C
- C) -0.93 degrees C
- D) 1.75 degrees C
- E) 1.86 degrees C

21. (1.00 pts)

If the boiling point of an aqueous solution containing 15 g of a nonelectrolyte in 150 mL water is -5.4°C . What is the molecular weight of the compound given $K_f = 1.86^{\circ}\text{C}/m$ for water.

- A) 2.78 g/mol
- B) 34.4 g/mol
- C) 41.2 g/mol
- D) 53.8 g/mol
- E) 121 g/mol

22. (1.00 pts) What is the K_{sp} for silver chromate at 25°C if its molar solubility is $65\ \mu\text{mol/L}$?

- A) 1.1×10^{-12}
- B) 6.5×10^{-5}
- C) 2.6×10^{-13}
- D) 4.7×10^{-6}

23. (1.00 pts) If the K_{sp} for chromium (III) iodate in water is 5.0×10^{-6} , then what is its molar solubility?

- A) 1.4 mmol/L
- B) 15 mmol/L
- C) 21 mmol/L
- D) 50 mmol/L

24. (1.00 pts) What is the solubility of silver chloride in $1.0 \times 10^{-4}\ \text{M NaCl}$?

- A) 1.0×10^{-4}
- B) 1.6×10^{-10}
- C) 1.6×10^{-6}
- D) 3.7×10^{-8}

25. (1.00 pts) Buffer capacity is NOT affected by the concentration of the buffer.

- True
- False

26. (1.00 pts)

Buffers used to stabilize against the addition of acid have a high capacity when the amount of weak base in the buffer is greater than or equal to 10% of the amount of weak acid in the buffer, and vice versa.

True False

27. (1.00 pts) In a titration, the stoichiometric point and the end point are the same thing.

True False

28. (4.00 pts) Which of the following are colligative properties?

(Mark ALL correct answers)

- A) Boiling point elevation
- B) Freezing point depression
- C) Osmotic pressure
- D) Vapor pressure raising

29. (3.00 pts) These acids are defined as proton donors and these bases are defined as proton acceptors.

(Mark ALL correct answers)

- A) Bronsted acids and bases
- B) Arrhenius acids and bases
- C) Lewis acids and bases

30. (3.00 pts) These acids and bases are only defined in aqueous solutions.

(Mark ALL correct answers)

- A) Bronsted acids and bases
- B) Arrhenius acids and bases
- C) Lewis acids and bases

31. (3.00 pts) These acids are defined as electron pair acceptors and these bases are defined as electron pair donors.

(Mark ALL correct answers)

- A) Bronsted acids and bases
- B) Arrhenius acids and bases
- C) Lewis acids and bases

32. (3.00 pts) What type of acid is HNO_3 ?

(Mark ALL correct answers)

- A) Bronsted acid
- B) Arrhenius acid
- C) Lewis acid

33. (3.00 pts) What type of base is NaOH ?

(Mark ALL correct answers)

- A) Bronsted base
- B) Arrhenius base
- C) Lewis base

34. (3.00 pts) What kind of base is NH_3 ?

(Mark ALL correct answers)

- A) Bronsted base
- B) Arrhenius base
- C) Lewis base

35. (3.00 pts) What type of base is CO_3^{2-} ?

(Mark ALL correct answers)

- A) Bronsted base
- B) Arrhenius base
- C) Lewis base

36. (2.00 pts) Metals tend to form ___ oxides while nonmetals tend to form ___ oxides.

basic

acidic

37. (2.00 pts) ___ substances are able to react with both acids and bases, with some examples being Be and Po, as well as oxides formed from some d-block metals. ___ substances can act as both a proton donor and a proton acceptor; they are always in equilibrium in water and aqueous solutions.

amphoteric

amphiprotic

38. (4.00 pts)

Calculate the initial molarity of $\text{Ba}(\text{OH})_2$ and the molarities of Ba^{2+} , OH^- , and H_3O^+ in an aqueous solution that contains 0.43 g of $\text{Ba}(\text{OH})_2$ in 0.100 L of solution.

Expected Answer: $\text{Ba}(\text{OH})_2$: 2.5×10^{-2} M Ba^{2+} : 2.5×10^{-2} M OH^- : 5.0×10^{-2} M H_3O^+ : 2.0×10^{-13} M

39. (2.00 pts)

Arrange the following bases in order of increasing strength on the basis of the pK_a values of their conjugate acids, which are given in parentheses: ammonia (9.26), methylamine (10.56), ethylamine (10.81), aniline (4.63).

Expected Answer: Aniline, ammonia, methylamine, ethylamine

40. (5.00 pts)

Suppose that 1.436 g of impure sodium hydroxide is dissolved in 300. mL of aqueous solution and that 25.00 mL of this solution is titrated to the stoichiometric point with 34.20 mL of 0.0695 M HCl(aq). What is the percentage purity of the original sample?

Expected Answer: 79.5% (will accept 79.4%)

41. (5.00 pts)

Suppose that 4.25 g of an unknown monoprotic weak acid, HA, is dissolved in water. Titration of the solution with 0.350 M NaOH(aq) required 52.0 mL to reach the stoichiometric point. After the addition of 26.0 mL, the pH of the solution was found to be 3.82. What is the molar mass of the acid?

Expected Answer: 234 g/mol

42. (2.00 pts) Will lead (II) iodide precipitate if you mix equal volumes of 0.2 M Pb(NO)₃ and KI?

Expected Answer: Yes (I gave points as long as you answered yes, as I realized I forgot to provide the K_{sp} for PbI₂. HOWEVER, the answer is yes NOT because the compound is always insoluble in water, but you need to do calculations comparing the solubility product constant to the reaction quotient of the equilibrium.)

43. (5.00 pts) Calculate the molar solubility of silver chloride in 0.10 M NH₃, if K_{sp} = 1.6 × 10⁻¹⁰ for silver chloride and K_f = 1.6 × 10⁷ for the ammonia complex of Ag⁺ ions.

Expected Answer: 4.6 × 10⁻³

44. (2.00 pts) Explain what happens to the concentration of H₃O⁺ ions in an acetic acid solution when solid sodium acetate is added.

Expected Answer: When solid sodium acetate is added to an acetic acid solution, the concentration of H₃O⁺ decreases.

45. (2.00 pts) Explain what happens to the percentage deprotonation of benzoic acid in a benzoic acid solution when hydrochloric acid is added.

Expected Answer: The percentage of benzoic acid that is deprotonated decreases.

46. (2.00 pts) Explain what happens to the pH of the solution when solid ammonium chloride is added to aqueous ammonia.

Expected Answer: The concentration of OH⁻ decreases, so pH decreases.

47. (2.00 pts) 15.2 mg of CrCl₃ is dissolved in 2.50 L of water. What is the concentration of this solution in ppm?

Expected Answer: 6.08 ppm

48. (2.00 pts) How many grams of solid K₂Cr₂O₇ is needed to make 1.00 L of an aqueous solution of 0.200 M K₂Cr₂O₇?

Expected Answer: 58.8 g

49. (2.00 pts)

A test tube with 5 mL of water is heated to 80°C. 0.94 g of a solute is then added to this test tube and dissolves. The test is then cooled while being continuously stirred. The first signs of crystallization happen at 50°C. How many grams of the solute would precipitate if 25 g is added to 50 g of water at 50°C?

Expected Answer: 15.6 g

50. (2.00 pts)

If the same experiment as the previous question was done but with 0.5 g of solute, the first signs of crystallization would appear at 30°C. How many grams of solute would dissolve in 30 g of water at 30°C?

Expected Answer: 3 g

51. (10.00 pts) Write a procedure to figure out the molarity of a 25.0 mL solution of HCl given 0.100 M NaOH and using phenolphthalein as an indicator.

Expected Answer: 1. Pour the HCl into an Erlenmeyer flask, adding 2-3 drops of phenolphthalein. 2. Pour the NaOH into a buret and record the initial volume. 3. Slowly add the NaOH into the flask while swirling the flask to mix, every once in awhile washing down the sides with distilled water. 4. Once pink begins to appear, start adding the NaOH drop by drop until the solution in the flask remains a light pink color. 5. Record the final volume of NaOH in the buret, and subtract the initial volume. 6. Multiply this calculated volume (in liters) by the molarity of NaOH, and then divide by 0.0250 L of HCl to get the molarity of the HCl solution.

52. (2.00 pts) If the titration in the last problem required 87.5 mL of NaOH to reach the end point, what is the concentration of the HCl solution?

Expected Answer: 0.350 M

53. (5.00 pts)

In a titration, distilled water is often used to wash down the sides of the flask to get any acid or base stuck on the sides to go into the solution to get more accurate results. Explain why the added water does not instead skew the results. (e.g.: Why does the added volume not affect results? Why does the dilution of the analyte during the titration not affect how much titrant is needed to get to the stoichiometric point?)

Expected Answer: The initial volume of the analyte is already recorded before the titration starts, so how much water is added doesn't matter. Also, the amount of titrant needed to neutralize the analyte depends on the moles of hydrogen ions that the analyte can donate/accept, so the addition of water does not affect this amount.