The SAT Subject Tests™

Answer Explanations

TO PRACTICE QUESTIONS FROM *THE SAT SUBJECT TESTS STUDENT GUIDE*

Chemistry

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CollegeBoard SAT®

SAT Subject Test in Chemistry

This document gives detailed answer explanations to chemistry practice questions from *The SAT Subject Tests™ Student Guide*. By reviewing them, you'll get to know the types of questions on the test and learn your strengths and weaknesses. Estimated difficulty level is based on a 1–5 scale, with 1 the easiest and 5 the most difficult.

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1. **Difficulty:** 2

   Choice (C) is correct. To answer this question, you must recognize which of the choices are acid solutions. Only choices (A) and (C) satisfy this requirement. Choice (B) refers to a neutral salt solution, choice (D) is a solution of an alcohol, and choice (E) is a basic solution. Choice (A) is made with a strong acid that is completely ionized in aqueous solution, whereas choice (C) is made with a weak acid that is only partially ionized in aqueous solution. The hydrogen ion concentration in choice (A) is 0.1 molar, whereas the hydrogen ion concentration in choice (C) is considerably less than 0.1 molar. Thus, the correct choice is choice (C), a weakly acidic solution.

2. **Difficulty:** 3

   Choice (E) is correct. To answer this question, you need to understand the pH scale, which is a measure of the hydrogen ion concentration in solution and is defined as $pH = -\log [H^+]$. The higher the pH, the lower the hydrogen ion concentration and the more basic the solution. Among the choices given above, choice (E) is the most basic solution.

3. **Difficulty:** 4

   Choice (A) is correct. To answer this question, you need to know that acids react with bases to form salts and water. Because the question refers to equal volumes of each solution, assume 1 liter of each solution is available. Barium hydroxide solution is a strong base (i.e., it is completely ionized in water), and 1 liter of 0.05 M $Ba(OH)_2$ provides 0.1 mole of OH^- ions in solution. When 1 liter of this solution is added to 1 liter of either 0.1 M NaCl, 0.1 M CH_3OH or 0.1 M KOH, no reactions occur and the resulting solutions remain basic; that is, the pH will be greater than 7 in each case. When 0.1 mole of OH^- ions reacts with 0.1 mole of acetic acid, the resulting solution will also be basic and have a pH greater than 7 because acetic acid is a weak acid (i.e., it is incompletely ionized in water). The acetic acid reacts with the OH^- ions as follows:

   $$HC_2H_3O_2 + OH^- \rightleftarrows C_2H_3O_2^- + H_2O$$

   The acetate ion produced is a base, which hydrolyzes in water to yield a solution containing more OH^- ions than H^+ ions. When 1 liter of 0.05 M $Ba(OH)_2$ reacts with 1 liter of 0.1 M HCl, there is a reaction between 0.1 mole of OH^- ions and 0.1 mole of H^+ to form 0.1 mole of H_2O. The resulting solution contains Ba^{2+} ions and Cl^- ions and equal concentrations of OH^- and H^+ ions. The solution formed is neutral, and the pH is 7; therefore, choice (A) is the correct answer.

4. **Difficulty:** 3

   Choice (A) is correct. The chemical formula of sodium acetate is $NaC_2H_3O_2$. The sodium ion is Na^+, and the acetate ion is $C_2H_3O_2^-$. The Na^+ ion has the form X^+.

5. **Difficulty:** 1

   Choice (C) is correct. The chemical formula of aluminum oxide is Al_2O_3. The aluminum ion is Al^{3+}, and the oxide ion is O^{2-}. The Al^{3+} ion has the form X^{3+}.

6. **Difficulty:** 2

   Choice (A) is correct. The chemical formula of potassium phosphate is K_3PO_4. The potassium ion is K^+, and the phosphate ion is PO_4^{3-}. The K^+ ion has the form X^+, and the phosphate ion has the form XO_4^{3-}; therefore the correct answer is choice (A).

7. **Difficulty:** 3

   Choice (C) is correct. The highest principal quantum number in this electron configuration is 3 (valence electrons $3s^2\ 3p^4$), so the element is in the third period of the periodic table. The atom has two *s* and four *p* valence electrons, so it is in the oxygen group. The atom is therefore an atom of sulfur.

8. **Difficulty:** 3

   Choice (A) is correct. The Ca^{2+} ion is a Ca atom that has lost two electrons. Ca has an atomic number of 20 and has 20 electrons, so Ca_2^+ must have 18 electrons. The neutral atom with 18 electrons (and 18 protons) is Ar. Note that Ar is two elements before Ca in the periodic table.

9. Difficulty: 2

Choice (E) is correct. The element with the lowest atomic number that has any electrons in an *f* orbital is cerium (atomic number 58), which has the electron configuration [Xe] $6s^2\, 4f^1\, 5d^1$. All elements with an atomic number equal to or greater than 58 have ground-state atoms with electrons in *f* orbitals. Uranium has an atomic number of 92; therefore, the correct answer is (E).

10. Difficulty: 2

Choice (A) is correct. Argon is a noble gas, and noble gases are relatively unreactive.

101. Difficulty: 3

Both statements are true, and statement II gives the reason that statement I is correct. The correct answer is therefore true, true, correct explanation.

102. Difficulty: 3

It is true that diamond melts at a very high temperature (over 3,500°C). Substances with ionic bonding do have high melting points, but the bonding in diamond is network covalent, not ionic. (Note that unless both statements are true, it is not necessary to determine whether the second statement is a correct explanation of the first statement.) The correct answer is true, false.

103. Difficulty: 3

Ionization energy depends on effective nuclear charge and the distance of the electron from the nucleus. Outer electrons are partially shielded from the nucleus by inner electrons, so the effective nuclear charge is about the same for atoms of elements in the same group of the periodic table. Potassium (K) and lithium (Li) are in the same group of the periodic table, but the Li atom has fewer occupied shells and a smaller atomic radius. The outermost electron in Li is in a shell that is close to the nucleus, and the outermost electron in K is in a shell that is relatively far from the nucleus. Therefore, there is less attraction between the outermost electron in a K atom and its nucleus than between the outermost electron in a Li atom and its nucleus, and it is easier to remove an electron from a K atom, resulting in a lower first ionization energy for K than for Li. It is true that K (atomic number 19) has more protons in its nucleus than does Li (atomic number 3), but this is not the reason for the relative ionization energies. (Note, for example, that Ca has more protons in its nucleus than does K, but Ca has a higher first ionization energy than does K.) The correct answer is true, true, not a correct explanation.

104. Difficulty: 4

In the activity series, Zn is relatively easy to oxidize to Zn^{2+}, while Cu is relatively inactive. Therefore, if Zn metal were placed in a solution containing Cu^{2+} ions, Zn would be oxidized to Zn^{2+} ions, and Cu^{2+} would be reduced to Cu metal. Both statements are true, and statement II gives the reason that statement I is correct. The correct answer is therefore true, true, correct explanation.

105. Difficulty: 5

When a system at equilibrium is disturbed, the system will shift in a way that partially offsets the effect of the disturbance (Le Châtelier's principle). Thus, when $HC_2H_3O_2$ is added to the equilibrium mixture, the equilibrium will shift to the right. This increases the concentration of $C_2H_3O_2^-$ and H_3O^+. Statement I is therefore false. Changes in the concentrations of reactants and products do not affect the value of the equilibrium constant; if the temperature does not change, the value of the equilibrium constant does not change. Statement II is therefore false. The correct answer is false, false.

11. Difficulty: 3

Choice (C) is correct. This is a question that concerns the concentration of a diluted solution. One way to solve the problem is through the use of ratios. In this question, a solution of nitric acid is diluted 10-fold; therefore, the concentration of the solution will decrease by a factor of 10, that is, from 0.100 molar to 0.010 molar. Alternatively, you could calculate the number of moles of H^+ ions present and divide this value by 0.50 liter: $(0.100 \times 0.050)/0.5 = M$ of the diluted solution.

12. Difficulty: 2

Choice (D) is correct. This question pertains to the balancing of chemical equations. To answer this question correctly, you need to recognize that both mass and charge must be conserved in any chemical equation. With this in mind, the chemical equation is correctly written as

$$2\ Cu^{2+}(aq) + 4\ I^-(aq) \rightarrow 2\ CuI(s) + I_2(s)$$

The coefficient for I^-*(aq)* is 4.

13. Difficulty: 4

Choice (C) is correct. This is a laboratory-oriented question pertaining to the measurement of gas pressures. It demands higher-level analytical skills that involve drawing conclusions from results obtained in an experiment. To answer this question correctly, you must first understand that, in an open type of manometer, the air exerts pressure on the column of liquid in the open side of the U-tube, and the gas being studied exerts pressure on the other side of the U-tube. It is clear, then, that statement I is true because the data given show that the manometer is open-ended, and its right side is exposed to the atmosphere. Statement II is also true because the level of liquid mercury is higher in the right side, which is exposed to the atmosphere, than in the left side, which is exposed to the gas. Thus the gas pressure is greater than atmospheric pressure. Statement III is not correct because the pressure of the gas in the bulb, expressed in millimeters of mercury, is equal to the difference in height, h, of the two mercury levels, plus the atmospheric pressure. Thus only statements I and II are true, and the correct answer is choice (C).

14. Difficulty: 3

Choice (B) is correct. This is a question on states of matter. You must convert the description of the physical phenomenon given in the question to graphical form. When a liquid is cooled slowly, its temperature will decrease with time. Thus the first portion of a graph depicting this phenomenon must show a decrease when temperature is plotted against time. When a pure liquid substance reaches its fusion (melting) point, there is no drop in temperature as the substance solidifies. After the substance has completely solidified, further cooling will cause an additional drop in temperature. The only graph shown that accurately depicts the events described is choice (B), which is the correct answer.

15. Difficulty: 3

Choice (A) is correct. This is a question on chemical bonding that requires you to apply the principles of molecular bonding. Each of the molecules given is correctly paired with the term describing its molecular geometry except choice (A). The geometry of PF_3 is not trigonal planar but trigonal pyramidal because this geometry corresponds to a maximum possible separation of the electron pairs around the central atom, phosphorus, and therefore yields the most stable configuration; the central atom of the molecule is surrounded by the three single bonds and one unshared electron pair. Thus, the correct answer is choice (A). Note that this is the type of question that asks you to identify the *one* solution to the problem that is *inappropriate*.

16. Difficulty: 2

Choice (C) is correct. This question tests your ability to balance chemical equations. The stoichiometry of the correctly balanced equation indicates that 2 moles of $SO_2(g)$ are needed to react completely with 1 mole of $O_2(g)$ to form 2 moles of SO_3.

17. Difficulty: 3

Choice (B) is correct. This is a question on stoichiometry that tests the important skill of scientific reasoning based on experimental evidence. The question indicates that 100 percent of the composition of the compound analyzed can be accounted for with the elements hydrogen and carbon. Thus, this compound is a hydrocarbon and choice (A) is a correct statement. It is not the correct answer to the question, however, because you can deduce more specific conclusions about this compound from the information given. The relative percentage composition provides evidence that the atomic ratio of carbon to hydrogen in the compound must be 86/12:14/1.0, or about 1:2. Therefore, you can conclude that the empirical formula for the compound is CH_2. Thus choice (B) is a better answer than choice (A). Because you do not know the total number of moles of the compound used for analysis, you cannot calculate the molar mass or derive the molecular formula for this compound. Therefore choices (C) and (D) cannot be determined from the information given and thus are not correct answers to the question. It is known, however, that a substance with an empirical formula of CH_2 cannot have a triple bond. Therefore choice (E) is incorrect.

18. Difficulty: 2

Choice (D) is correct. The molar mass of C_3H_8 is 44.0 g/mol. According to the equation, four moles of water are formed for each mole of propane combusted. The molar mass of water is 18.0 g/mol, so the mass of water formed is 18.0 g × 4 = 72.0 g.

19. Difficulty: 1

Choice (D) is correct. Each mole of $KHSO_4$ contains four moles of oxygen atoms, so 0.50 mol of $KHSO_4$ contains two moles of oxygen atoms. One mole is 6.0×10^{23}, and $2\,(6.0 \times 10^{23}) = 12 \times 10^{23} = 1.2 \times 10^{24}$.

20. Difficulty: 3

Choice (E) is correct. Air contains mostly N_2 (molar mass 28 g/mol) and O_2 (molar mass 32 g/mol). The molar mass of carbon dioxide is 44 g/mol, so carbon dioxide is *more* dense than air. The other statements are true and are not correct choices.

21. Difficulty: 3

Choice (D) is correct. Going down a group of the periodic table, atomic radius and atomic mass increase. Because effective nuclear charge is about the same within a group and radius increases going down a group, ionization energy *decreases* going down a group.

22. Difficulty: 4

Choice (E) is correct. In aqueous solution, HI can donate a proton and form I^-, NH_4^+ can donate a proton to form NH_3, HCO_3^- can donate a proton to form CO_3^{2-}, and H_2S can donate a proton to form HS^-. NH_3 does not donate a proton in aqueous solution to form NH_2^-; therefore, choice (E) is the correct answer.

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