



## **International Subject Test— Chemistry Practice Test**

The ACT<sup>®</sup> International Subject Test—Chemistry Practice Test is an official AIST practice test. The full-length Chemistry Practice Test consists of items drawn from the International Subject Test Chemistry formative assessment pool and adheres to the AIST Chemistry Test Specifications.

This PDF file includes Chemistry Practice Test questions and answer keys. Taking the AIST Official full-length practice test is the best way to prepare for the two sessions of the AIST Chemistry test.

# Chemistry

## Part 1

*45 Minutes—38 Questions*

For each question, choose the best answer and select the circle next to it. If you change your mind about an answer, choose a different answer and select the circle next to it.

You are permitted to use an approved calculator on this test. A Periodic Table of Elements and a Reference Sheet have been included in this Chemistry Practice Test, beginning on the next page.

Your score will be based only on the number of questions you answer correctly during the time allowed. You will **not** be penalized for guessing. **It is to your advantage to answer every question even if you must guess.**

If you finish before time ends, you should use the time remaining to reconsider questions you are uncertain about.

Periodic Table of the Elements

1 <b>H</b> 1.008																	2 <b>He</b> 4.003	
3 <b>Li</b> 6.941	4 <b>Be</b> 9.012															9 <b>F</b> 19.00	10 <b>Ne</b> 20.18	
11 <b>Na</b> 22.99	12 <b>Mg</b> 24.31															17 <b>Cl</b> 35.45	18 <b>Ar</b> 39.95	
19 <b>K</b> 39.10	20 <b>Ca</b> 40.08	21 <b>Sc</b> 44.96	22 <b>Ti</b> 47.88	23 <b>V</b> 50.94	24 <b>Cr</b> 52.00	25 <b>Mn</b> 54.94	26 <b>Fe</b> 55.85	27 <b>Co</b> 58.93	28 <b>Ni</b> 58.69	29 <b>Cu</b> 63.55	30 <b>Zn</b> 65.38	31 <b>Ga</b> 69.72	32 <b>Ge</b> 72.59	33 <b>As</b> 74.92	34 <b>Se</b> 78.96	35 <b>Br</b> 79.90	36 <b>Kr</b> 83.80	
37 <b>Rb</b> 85.47	38 <b>Sr</b> 87.62	39 <b>Y</b> 88.91	40 <b>Zr</b> 91.22	41 <b>Nb</b> 92.91	42 <b>Mo</b> 95.94	43 <b>Tc</b> (98)	44 <b>Ru</b> 101.1	45 <b>Rh</b> 102.9	46 <b>Pd</b> 106.4	47 <b>Ag</b> 107.9	48 <b>Cd</b> 112.4	49 <b>In</b> 114.8	50 <b>Sn</b> 118.7	51 <b>Sb</b> 121.8	52 <b>Te</b> 127.6	53 <b>I</b> 126.9	54 <b>Xe</b> 131.3	
55 <b>Cs</b> 132.9	56 <b>Ba</b> 137.3	57 <b>La*</b> 138.9	72 <b>Hf</b> 178.5	73 <b>Ta</b> 180.9	74 <b>W</b> 183.9	75 <b>Re</b> 186.2	76 <b>Os</b> 190.2	77 <b>Ir</b> 192.2	78 <b>Pt</b> 195.1	79 <b>Au</b> 197.0	80 <b>Hg</b> 200.6	81 <b>Tl</b> 204.4	82 <b>Pb</b> 207.2	83 <b>Bi</b> 209.0	84 <b>Po</b> (209)	85 <b>At</b> (210)	86 <b>Rn</b> (222)	
87 <b>Fr</b> (223)	88 <b>Ra</b> 226.0	89 <b>Ac†</b> (227)	104 <b>Rf</b> (261)	105 <b>Db</b> (262)	106 <b>Sg</b> (263)	107 <b>Bh</b> (264)	108 <b>Hs</b> (265)	109 <b>Mt</b> (268)	110 <b>Ds</b> (281)									
			58 <b>Ce</b> 140.1	59 <b>Pr</b> 140.9	60 <b>Nd</b> 144.2	61 <b>Pm</b> (145)	62 <b>Sm</b> 150.4	63 <b>Eu</b> 152.0	64 <b>Gd</b> 157.3	65 <b>Tb</b> 158.9	66 <b>Dy</b> 162.5	67 <b>Ho</b> 164.9	68 <b>Er</b> 167.3	69 <b>Tm</b> 168.9	70 <b>Yb</b> 173.0	71 <b>Lu</b> 175.0		
			90 <b>Th</b> 232.0	91 <b>Pa</b> (231)	92 <b>U</b> 238.0	93 <b>Np</b> (237)	94 <b>Pu</b> (244)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (252)	100 <b>Fm</b> (257)	101 <b>Md</b> (258)	102 <b>No</b> (259)	103 <b>Lr</b> (260)		

## Chemistry Reference Sheet

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### Atomic Structure

$$E = h\nu$$

$$c = \lambda\nu$$

$E$  = energy

$h$  = Planck's constant =  $6.63 \times 10^{-34}$  J·s

$\nu$  = frequency

$c$  = speed of light =  $3.0 \times 10^8$  m/s

$\lambda$  = wavelength

$N_A$  = Avogadro's number =  $6.02 \times 10^{23}$  mol<sup>-1</sup>

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### Gases

$$d = \frac{m}{V}$$

$$T(\text{K}) = ^\circ\text{C} + 273$$

$$P_{\text{total}} = P_A + P_B + P_C + \dots$$

$$PV = nRT$$

$$n = \frac{m}{M}$$

$$d = \frac{PM}{RT}$$

$$P_1V_1 = P_2V_2$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$d$  = density (solids, liquids, and gases)

$m$  = mass

$V$  = volume

$T$  = temperature

$P$  = pressure

$n$  = number of moles

$R$  = gas constant = 0.0821 L·atm/mol·K

$M$  = molar mass

STP = 1.00 atm and 0.00°C

1 atm = 760 mm Hg = 760 torr = 101.3 kPa

1 mol of ideal gas = 22.4 L at STP

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### Percent Yield and Percent Error

$$\% \text{ Yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

$$\% \text{ Error} = \frac{|\text{accepted value} - \text{experimental value}|}{\text{accepted value}} \times 100$$

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## Liquids and Solutions

$$\text{Percent (mass/mass)} = \frac{\text{mass of solute (g)}}{\text{mass of solution (g)}} \times 100$$

$$M = \frac{\text{moles of solute}}{\text{L of solution}}$$

$$m = \frac{\text{moles of solute}}{\text{kg of solvent}}$$

$$X_A = \frac{\text{moles}_A}{\text{moles}_{\text{total}}}$$

$$M_1V_1 = M_2V_2$$

$$\Delta T_f = K_f \times m$$

$$\Delta T_b = K_b \times m$$

$M$  = molarity

$m$  = molality

$X_A$  = mole fraction of component A

$V$  = volume

$\Delta T$  = temperature change

$K_f$  = molal freezing point depression constant

$K_f(\text{H}_2\text{O}) = 1.86^\circ\text{C}/m$

$K_b$  = molal boiling point elevation constant

$K_b(\text{H}_2\text{O}) = 0.512^\circ\text{C}/m$

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## Calorimetry and Thermodynamics

$$q = mC\Delta T$$

$$\Delta H_{\text{rxn}}^\circ = \Delta H_f^\circ(\text{products}) - \Delta H_f^\circ(\text{reactants})$$

$$\Delta S_{\text{rxn}}^\circ = S^\circ(\text{products}) - S^\circ(\text{reactants})$$

$q$  = heat

$m$  = mass

$C$  = specific heat capacity

$C(\text{H}_2\text{O}) = 4.184 \text{ J/g}\cdot^\circ\text{C}$

$\Delta T$  = temperature change

$\Delta H^\circ$  = standard enthalpy change

$\Delta S^\circ$  = standard entropy change

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## Acids, Bases, and Equilibrium

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

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

$$\text{pH} + \text{pOH} = 14$$

$$K_w = [\text{H}^+][\text{OH}^-]$$

$$K_{\text{eq}} = \frac{[\text{C}]^c[\text{D}]^d}{[\text{A}]^a[\text{B}]^b} \text{ where } a\text{A} + b\text{B} \rightleftharpoons c\text{C} + d\text{D}$$

$$K_{\text{sp}} = [\text{A}^+]^a[\text{B}^-]^b \text{ where } \text{A}_a\text{B}_b(s) \rightleftharpoons a\text{A}^+(aq) + b\text{B}^-(aq)$$

$[\text{H}^+]$  =  $\text{H}^+$  molarity

$[\text{OH}^-]$  =  $\text{OH}^-$  molarity

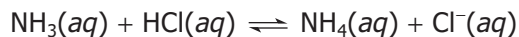
$K_w$  = ion-product constant for water

$K_w = 1.0 \times 10^{-14}$  at  $25^\circ\text{C}$

$K_{\text{eq}}$  = equilibrium constant

$K_{\text{sp}}$  = solubility product constant

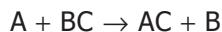
1. Ammonia reacts with hydrochloric acid to produce ammonium ions and chloride ions, as shown in this equilibrium.



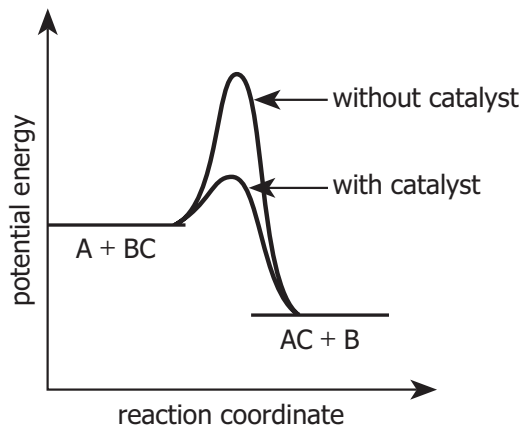
Which of the following is the role of  $\text{NH}_3$  in this equilibrium?

- A. Arrhenius acid
  - B. Arrhenius base
  - C. Brønsted–Lowry acid
  - D. Brønsted–Lowry base
2. Anything that takes up space and has mass can be referred to as which of the following?
- A. Compound
  - B. Matter
  - C. Mixture
  - D. Element
3. Which of the following statements is always correct for a compound?
- A. It has a constant composition.
  - B. It contains only 1 element.
  - C. It is soluble in water.
  - D. It decomposes by physical means.
4. At high temperatures, chlorine reacts with fluorine to produce chlorine trifluoride.
- $$\text{Cl}_2(g) + 3\text{F}_2(g) \rightarrow 2\text{ClF}_3(g)$$
- A chemist carries out the reaction of 0.250 mol of  $\text{F}_2$  with excess  $\text{Cl}_2$ . At  $250.0^\circ\text{C}$  and 1.00 atm, what is the maximum volume of  $\text{ClF}_3$  that the reaction can produce?
- A. 3.42 L
  - B. 3.73 L
  - C. 7.16 L
  - D. 10.7 L

5. In chemistry lab, 2 students studied this reaction.



They carried out the reaction with a catalyst and again without a catalyst. Then, they displayed their results in this diagram.



Which statement correctly describes their results?

- A. Adding a catalyst decreased the activation energy of the reaction.
  - B. Adding a catalyst increased the activation energy of the reaction.
  - C. Adding a catalyst decreased the potential energy of the products.
  - D. Adding a catalyst increased the potential energy of the products.
6. Calcium chloride reacts with sodium phosphate to produce calcium phosphate and sodium chloride.
- $$3\text{CaCl}_2(aq) + 2\text{Na}_3\text{PO}_4(aq) \rightarrow \text{Ca}_3(\text{PO}_4)_2(s) + 6\text{NaCl}(aq)$$
- When a chemist adds 200.0 mL of 0.150 M  $\text{CaCl}_2(aq)$  to 115.0 mL of 0.250 M  $\text{Na}_3\text{PO}_4(aq)$ , what is the maximum number of moles of  $\text{Ca}_3(\text{PO}_4)_2$  that the reaction can produce?
- A. 0.0100 mol
  - B. 0.0144 mol
  - C. 0.0288 mol
  - D. 0.0300 mol
7. What is the molar mass of  $\text{Al}(\text{NO}_3)_3$ ?
- A. 88.99 g/mol
  - B. 151.00 g/mol
  - C. 165.01 g/mol
  - D. 213.01 g/mol

8. As the wavelength of a light wave increases, how are the energy and the frequency affected?
- A. The energy increases and the frequency increases.
  - B. The energy increases and the frequency decreases.
  - C. The energy decreases and the frequency decreases.
  - D. The energy decreases and the frequency increases.
9. At 25°C, the solubility product constant ( $K_{sp}$ ) for  $MgF_2$  is  $3.70 \times 10^{-8}$ . During chemistry class, Chenise prepares a saturated aqueous solution of  $MgF_2$  at 25°C. What is the concentration of  $F^-$  in the saturated solution?
- A.  $1.36 \times 10^{-4} M$
  - B.  $2.10 \times 10^{-3} M$
  - C.  $3.33 \times 10^{-3} M$
  - D.  $4.20 \times 10^{-3} M$
10. Which of the following chemical reactions involves an increase in the entropy of the system?
- A.  $CO_2(g) \rightarrow CO_2(s)$
  - B.  $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$
  - C.  $2NaN_3(s) \rightarrow 2Na(l) + 3N_2(g)$
  - D.  $Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$
11. Methane reacts with chlorine to produce carbon tetrachloride and hydrogen chloride.
- $$CH_4(g) + 4Cl_2(g) \rightarrow CCl_4(l) + 4HCl(g)$$
- A student carries out the reaction of 5.00 g of  $CH_4$  with 82.5 g of  $Cl_2$ . What is the maximum mass of  $CCl_4$  that the reaction can produce?
- A. 17.5 g
  - B. 44.7 g
  - C. 47.9 g
  - D. 87.5 g
12. At high temperatures, solid  $SnO_2$  reacts with solid C to produce molten Sn and CO gas. What is the correct balanced chemical equation for this reaction, including the appropriate symbols of state for each substance?
- A.  $SnO_2(l) + C(s) \rightarrow Sn(s) + CO(g)$
  - B.  $SnO_2(s) + C(s) \rightarrow Sn(l) + CO(g)$
  - C.  $SnO_2(l) + 2C(s) \rightarrow Sn(s) + 2CO(g)$
  - D.  $SnO_2(s) + 2C(s) \rightarrow Sn(l) + 2CO(g)$




- 13.** Kelly increases the volume of a fixed amount of a gas at constant temperature. Which of the following statements explains how increasing the volume affects the pressure of the gas?
- A.** The pressure decreases because there are fewer collisions between gas molecules and the container walls.
  - B.** The pressure decreases because there are more collisions between gas molecules and the container walls.
  - C.** The pressure increases because there are fewer collisions between gas molecules and the container walls.
  - D.** The pressure increases because there are more collisions between gas molecules and the container walls.
- 14.** A student observes the combustion of propane ( $C_3H_8$ ). Because of the heat and light it generates, the student concludes that the reaction has NO activation energy. Is the student's conclusion correct, and why?
- A.** Yes; because the propane is flammable, there is no activation energy.
  - B.** Yes; because the reaction generates heat, there is no activation energy.
  - C.** No; because the reaction requires an ignition source, it does have an activation energy.
  - D.** No; because the reaction generates light, it does have an activation energy.
- 15.** What is the electron configuration of the chromium ion in  $CrO_3$ ?
- A.**  $[Ar]$
  - B.**  $[Ar] 3d^3$
  - C.**  $[Ar] 4s^2 3d^1$
  - D.**  $[Ar] 4s^2 3d^4$
- 16.** Phosgene ( $COCl_2$ ) decomposes to produce carbon monoxide ( $CO$ ) and chlorine ( $Cl_2$ ) in this equilibrium reaction.
- $$COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g)$$
- A chemist performs this reaction in a 2 L container and obtains a 7.0% yield of  $Cl_2$ . How can the chemist improve the percent yield of  $Cl_2$  in this equilibrium reaction?
- A.** By reducing the volume of the container
  - B.** By increasing the volume of the container
  - C.** By using a smaller amount of  $COCl_2$
  - D.** By adding  $CO$

17. This table shows the percent composition data for aspartame, an artificial sweetener used in many diet soft drinks.

Element	% Composition
C	57.133
H	6.165
N	9.521
O	27.181

What is the empirical formula of aspartame?

- A.  $C_5H_6NO_2$   
 B.  $C_7H_9NO_3$   
 C.  $C_9HN_2O_4$   
 D.  $C_{14}H_{18}N_2O_5$
18. Jovan placed 10 mL of aqueous  $Al_2(SO_4)_3$  into 2 separate test tubes. Then, he added a 2 g sample of Mg metal into one test tube and a 2 g sample of Cu metal into the other test tube. A reaction occurred in only 1 tube. Use this table to determine which balanced chemical reaction occurred.

Activity Series of Metals		
decreasing activity 	Lithium	Li
	Potassium	K
	Calcium	Ca
	Sodium	Na
	Magnesium	Mg
	Aluminum	Al
	Zinc	Zn
	Iron	Fe
	Lead	Pb
	Copper	Cu
	Silver	Ag

- A.  $3Mg(s) + Al_2(SO_4)_3(aq) \rightarrow 3MgSO_4(aq) + 2Al(s)$   
 B.  $3Mg(s) + Al_2(SO_4)_3(aq) \rightarrow 3MgO(s) + Al_2S_3(aq) + 3O_3(g)$   
 C.  $3Cu(s) + Al_2(SO_4)_3(aq) \rightarrow 3CuSO_4(aq) + 2Al(s)$   
 D.  $3Cu(s) + Al_2(SO_4)_3(aq) \rightarrow 3CuO(s) + Al_2S_3(aq) + 3O_3(g)$
19. The boiling point of pure liquid ethanol is  $78.5^\circ C$ . Which of the following statements correctly describes liquid ethanol while it is boiling?
- A. Its molecules donate enough kinetic energy that they can escape the liquid.  
 B. Its molecules acquire enough kinetic energy that they can escape the liquid.  
 C. Its vapor pressure is lower than atmospheric pressure.  
 D. Its vapor pressure is higher than atmospheric pressure.

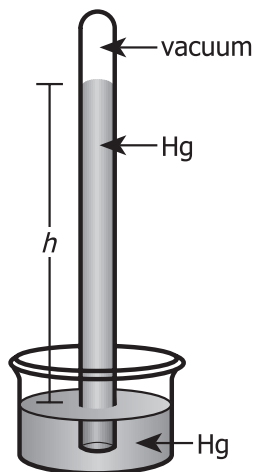
20. A chemistry student adds 0.50 mol of  $\text{CH}_3\text{OH}$  and 1.0 mol of  $\text{C}_3\text{H}_7\text{OH}$  to 2.0 mol of  $\text{H}_2\text{O}$  in a beaker. What is the mole fraction of  $\text{H}_2\text{O}$  in the resulting mixture?
- A. 0.57  
B. 0.29  
C. 0.14  
D. 0.11
21. A chemistry student has 4 empty cubes. Two of the cubes have 1 cm sides and masses of 0.5 g. The other two cubes have 2 cm sides and masses of 1.0 g. The student adds 1 or more balls to each cube, as shown in this table.

Cube	Side length (cm)	Mass of empty cube (g)	Number of balls added
A	1	0.5	1
B	1	0.5	2
C	2	1.0	8
D	2	1.0	11

The mass of each ball is 1.0 g. After the addition of the ball(s), which cube has the greatest density?

- A. Cube A  
B. Cube B  
C. Cube C  
D. Cube D

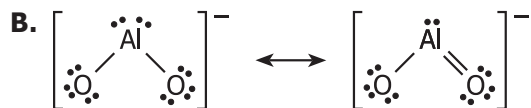
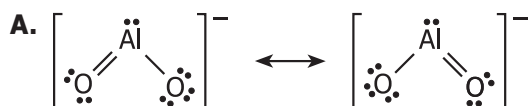
22. This diagram shows a closed-end mercury barometer.



At an atmospheric pressure of 1.30 atm, what would be the height ( $h$ ), in millimeters, of the Hg in the barometer?

- A. 132 mm Hg
- B. 585 mm Hg
- C. 760 mm Hg
- D. 988 mm Hg

23. In geology class, Lauren learns that the mineral chrysoberyl is an aluminate ( $\text{AlO}_2^-$ ) of beryllium (Be). Using her chemistry knowledge, she decides to draw the Lewis dot structure(s) of  $\text{AlO}_2^-$ , and she finds that there are several resonance structures of  $\text{AlO}_2^-$ . Which of the following shows 2 resonance structures of  $\text{AlO}_2^-$ ?



24. When heated, calcium carbonate decomposes to form calcium oxide and carbon dioxide.



Use the data in this table to calculate the standard enthalpy of reaction ( $\Delta H_{\text{rxn}}^\circ$ ) for the decomposition of  $\text{CaCO}_3$ .

Standard Enthalpies of Formation	
Substance	$\Delta H_f^\circ$ (kJ/mol)
$\text{CaCO}_3(s)$	-1,207.0
$\text{CaO}(s)$	-635.1
$\text{CO}_2(g)$	-393.5

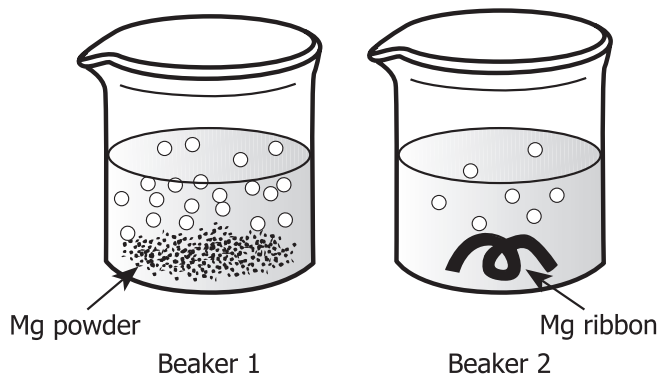
- A. 1,448.6 kJ  
B. 178.4 kJ  
C. -965.4 kJ  
D. -2,235.6 kJ
25. Boron trioxide,  $\text{B}_2\text{O}_3$ , reacts with water to produce boric acid,  $\text{B}(\text{OH})_3$ .
- $$\text{B}_2\text{O}_3(s) + 3\text{H}_2\text{O}(l) \rightarrow 2\text{B}(\text{OH})_3(s)$$
- Ricardo adds 27.2 g of  $\text{B}_2\text{O}_3$  to an excess of  $\text{H}_2\text{O}$ , and the reaction goes to completion. What mass of  $\text{B}(\text{OH})_3$  does the reaction produce?
- A. 12.1 g  
B. 24.2 g  
C. 48.3 g  
D. 61.2 g
26. The boiling point of chlorine is  $-34.6^\circ\text{C}$ . This corresponds to what Kelvin temperature?
- A. 307.6 K  
B. 238.4 K  
C.  $-238.4$  K  
D.  $-307.6$  K

27. A student measured the pH of some common household substances and recorded the results in this table.

Substance	pH
Lemon juice	2.3
Tomato juice	4.2
Black coffee	5.0
Milk of magnesia	10.5

Which substance has a  $H^+$  concentration greater than  $1.0 \times 10^{-4} M$ ?

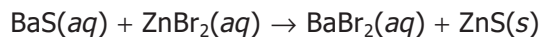
- A. Lemon juice  
B. Tomato juice  
C. Black coffee  
D. Milk of magnesia
28. Magnesium reacts with hydrochloric acid to produce hydrogen and magnesium chloride.
- $$Mg(s) + 2HCl(aq) \rightarrow H_2(g) + MgCl_2(aq)$$
- Megan adds equal masses of Mg powder to Beaker 1 and Mg ribbon to Beaker 2. She then adds 100.0 mL of 3.0 M HCl(aq) to each beaker. Both beakers are at the same temperature and pressure. Bubbles form more rapidly in Beaker 1 than in Beaker 2.



Which of the following statements accurately compares Beaker 1 and Beaker 2?

- A. The concentration of HCl is greater in Beaker 1.  
B. The density of the reaction mixture is lower in Beaker 2.  
C. The number of moles of reactants is lower in Beaker 2.  
D. The rate of the disappearance of Mg is greater in Beaker 1.

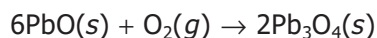
29. Aqueous barium sulfide reacts with aqueous zinc bromide to produce aqueous barium bromide and solid zinc sulfide.



What are the spectator ions in this reaction?

- A.  $\text{Ba}^{2+}$  and  $\text{Zn}^{2+}$
  - B.  $\text{Ba}^{2+}$  and  $\text{Br}^-$
  - C.  $\text{S}^{2-}$  and  $\text{Zn}^{2+}$
  - D.  $\text{S}^{2-}$  and  $\text{Br}^-$
30. Which of the following statements accurately compares the properties of ionic and covalent compounds? In general, ionic compounds:
- A. are less soluble in  $\text{H}_2\text{O}$  than covalent compounds.
  - B. have lower melting points than covalent compounds.
  - C. are not solids at room temperature, while covalent compounds are usually solids at room temperature.
  - D. conduct electricity when they are molten, while covalent compounds usually do not conduct electricity when they are molten.
31. What is the percent by mass of chlorine in  $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$ ?
- A. 14.5%
  - B. 17.0%
  - C. 29.0%
  - D. 34.1%
32. At very high temperatures, aluminum metal reacts with chromium(III) oxide to produce aluminum oxide and chromium metal. What is the balanced chemical equation for this reaction?
- A.  $2\text{Al}(s) + \text{CrO}_3(s) \rightarrow \text{Al}_2\text{O}_3(s) + \text{Cr}(l)$
  - B.  $2\text{Al}(s) + \text{Cr}_2\text{O}_3(s) \rightarrow \text{Al}_2\text{O}_3(s) + 2\text{Cr}(l)$
  - C.  $3\text{Al}(s) + \text{Cr}_3\text{O}_2(s) \rightarrow \text{Al}_3\text{O}_2(s) + 3\text{Cr}(l)$
  - D.  $6\text{Al}(s) + \text{Cr}_3\text{O}_4(s) \rightarrow 2\text{Al}_3\text{O}_2(s) + 3\text{Cr}(l)$
33. Which statement correctly describes 1 mole of  $\text{I}_2$ ?
- A. Its mass is 126.9 g.
  - B. Its mass is 380.7 g.
  - C. It contains  $6.02 \times 10^{23}$  atoms.
  - D. It contains  $6.02 \times 10^{23}$  molecules.

34. Consider this reaction:



Montel combined 15.3 g of PbO with excess  $\text{O}_2$ , and he obtained a 72.0% yield of  $\text{Pb}_3\text{O}_4$ . What mass of  $\text{Pb}_3\text{O}_4$  did the reaction produce?

- A. 33.8 g
- B. 21.3 g
- C. 11.3 g
- D. 3.67 g

35. At 15°C, 0.252 mol of Ar gas occupies 174 mL. The pressure of the Ar gas is:

- A. 1.78 atm.
- B. 2.92 atm.
- C. 12.6 atm.
- D. 34.2 atm.

36. Chemists add ammonium lauryl sulfate,  $\text{CH}_3(\text{CH}_2)_{11}\text{SO}_4\text{NH}_4$ , to shampoo to reduce the surface tension of water. How many hydrogen atoms are in 1 molecule of ammonium lauryl sulfate?

- A. 9
- B. 20
- C. 25
- D. 29

37. Which of the following elements is a metal in period 5 of the periodic table?

- A. Sr
- B. I
- C. Ca
- D. As

38. At room temperature, a student adds 125 g of solid glucose to a beaker containing 100 mL of water. He stirs the resulting mixture until no more glucose dissolves but some solid glucose remains in the water. Next, he heats the mixture until all the solid glucose dissolves. Then he removes the solution of glucose from the heat and slowly cools it to room temperature. No precipitate forms during the cooling process. He adds a small amount of solid glucose to the cooled solution, resulting in the formation of a precipitate. What is the best characterization of the cooled solution of glucose immediately prior to the addition of a small amount of solid glucose?

- A. Dilute
- B. Saturated
- C. Supersaturated
- D. Unsaturated



# International Subject Test— Chemistry Practice Test

## Part 1 Answer Key

The following table contains the question number and the correct answer (Key) for each question in Part 1 of this PDF file.

1	D
2	B
3	A
4	C
5	A
6	A
7	D
8	C
9	D
10	C
11	B
12	D
13	A
14	C
15	A
16	B
17	D
18	A
19	B

20	A
21	B
22	D
23	C
24	B
25	C
26	B
27	A
28	D
29	B
30	D
31	C
32	B
33	D
34	C
35	D
36	D
37	A
38	C

# Chemistry

## Part 2

*45 Minutes—38 Questions*

For each question, choose the best answer and select the circle next to it. If you change your mind about an answer, choose a different answer and select the circle next to it.

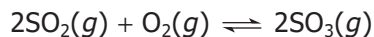
You are permitted to use an approved calculator on this test. A Periodic Table of Elements and a Reference Sheet have been included in this Chemistry Practice Test, beginning on page ii.

Your score will be based only on the number of questions you answer correctly during the time allowed. You will **not** be penalized for guessing. **It is to your advantage to answer every question even if you must guess.**

If you finish before time ends, you should use the time remaining to reconsider questions you are uncertain about.

1. Which of the following compounds is capable of forming hydrogen bonds?
- A.  $\text{BH}_3$
  - B.  $\text{CH}_4$
  - C.  $\text{HBr}$
  - D.  $\text{HF}$
2. Which of the following statements does NOT accurately describe acids or bases?
- A. Acids are corrosive.
  - B. Acids have endothermic reactions with water.
  - C. Bases have lower hydrogen ion ( $\text{H}^+$ ) concentrations than pure water.
  - D. Bases turn red litmus paper blue.
3. What is the correct balanced chemical equation for the complete combustion of octane ( $\text{C}_8\text{H}_{18}$ )?
- A.  $\text{C}_8\text{H}_{18}(l) + 4\text{O}_2(g) \rightarrow 8\text{CO}(g) + 9\text{H}_2(g)$
  - B.  $\text{C}_8\text{H}_{18}(l) + 8\text{O}_2(g) \rightarrow 8\text{CO}_2(g) + 9\text{H}_2(g)$
  - C.  $2\text{C}_8\text{H}_{18}(l) + 17\text{O}_2(g) \rightarrow 16\text{CO}(g) + 18\text{H}_2\text{O}(l)$
  - D.  $2\text{C}_8\text{H}_{18}(l) + 25\text{O}_2(g) \rightarrow 16\text{CO}_2(g) + 18\text{H}_2\text{O}(l)$
4. What is the chemical formula of calcium cyanide?
- A.  $\text{CaCN}$
  - B.  $\text{CaCN}_2$
  - C.  $\text{Ca}(\text{CN})_2$
  - D.  $\text{Ca}(\text{CN})_3$
5. For a chemistry homework assignment, Beth must consider the effusion rates of  $\text{CH}_4$  gas and  $\text{NF}_3$  gas at  $25^\circ\text{C}$ . Effusion occurs as gas particles escape from a container through a small hole. Which of the following statements best compares the effusion rates of  $\text{CH}_4$  and  $\text{NF}_3$  at  $25^\circ\text{C}$ ?
- A.  $\text{CH}_4$  effuses approximately 2 times faster than  $\text{NF}_3$ .
  - B.  $\text{CH}_4$  effuses approximately 4 times faster than  $\text{NF}_3$ .
  - C.  $\text{NF}_3$  effuses approximately 2 times faster than  $\text{CH}_4$ .
  - D.  $\text{NF}_3$  effuses approximately 4 times faster than  $\text{CH}_4$ .

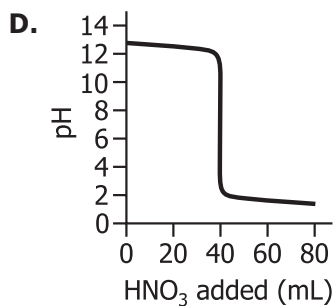
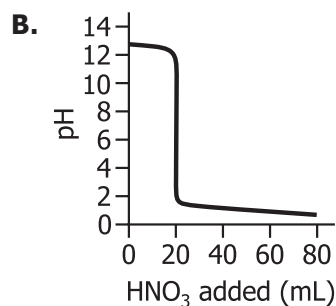
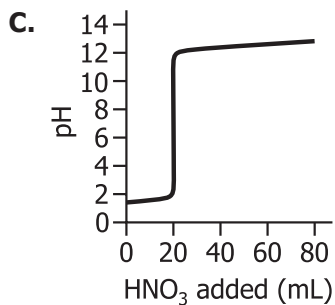
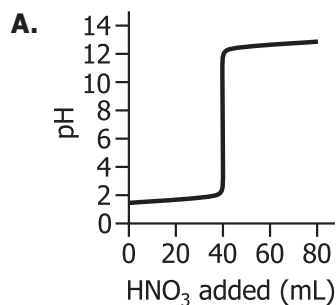
6. In a sealed 4.50 L vessel at a constant temperature, sulfur dioxide reacts with oxygen to produce sulfur trioxide.



At equilibrium, there are 1.50 mol of  $\text{SO}_2$ , 0.750 mol of  $\text{O}_2$ , and 2.25 mol of  $\text{SO}_3$ . What is the concentration equilibrium constant ( $K_{\text{eq}}$ ) for this reaction?

- A. 27.0  
B. 13.5  
C. 4.50  
D. 3.00
7. At 1.0 atm, a chemist heats a sample of solid caffeine. At 178°C, the solid converts directly into a gas. What is the name of this phase change?
- A. Sublimation  
B. Evaporation  
C. Crystallization  
D. Condensation
8. Oxygen gas reacts with aqueous hydrazine to produce aqueous hydrogen peroxide and nitrogen gas.
- $$2\text{O}_2(g) + \text{N}_2\text{H}_4(aq) \rightarrow 2\text{H}_2\text{O}_2(aq) + \text{N}_2(g)$$
- When 18.5 g of  $\text{O}_2$  reacts completely with excess  $\text{N}_2\text{H}_4$ , the reaction produces what mass of  $\text{N}_2$ ?
- A. 3.46 g  
B. 8.10 g  
C. 9.25 g  
D. 16.2 g
9. Using a Bunsen burner, Melina heats a 12.50 g sample of a hydrate of iridium(III) bromide in a large crucible to drive off all the associated water. After removing all the water, the mass of the anhydrous salt was 10.72 g. What is the empirical formula of the hydrate?
- A.  $\text{IrBr}_3 \cdot 2\text{H}_2\text{O}$   
B.  $\text{IrBr}_3 \cdot 3\text{H}_2\text{O}$   
C.  $\text{IrBr}_3 \cdot 4\text{H}_2\text{O}$   
D.  $\text{IrBr}_3 \cdot 5\text{H}_2\text{O}$

10. Jason must determine the concentration of sodium hydroxide in an aqueous solution. He knows that the concentration is approximately 0.2 M NaOH. Which titration curve would most likely result from titrating 20.0 mL of the NaOH solution with aqueous 0.100 M HNO<sub>3</sub>?



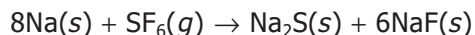
11. Dr. Estevez developed Molecule X as a new biodegradable treatment for ice on roads. Molecule X is very soluble in water, and it does not corrode automobiles. Molecule X is nonvolatile, and it is a nonelectrolyte. When Dr. Estevez dissolves 4.25 mol of Molecule X in 3.00 kg of H<sub>2</sub>O, what is the freezing point of the resulting solution?

- A. -1.31°C  
 B. -2.33°C  
 C. -2.64°C  
 D. -7.92°C

12. What is the orbital diagram for the outermost electrons in a ground-state chlorine atom?

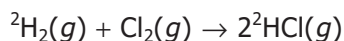
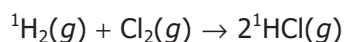
- A. 3s  $\uparrow\downarrow$  3p  $\uparrow\downarrow$   $\uparrow\uparrow$   $\uparrow$   
 B. 3s  $\uparrow\downarrow$  3p  $\uparrow\downarrow$   $\uparrow\downarrow$   $\uparrow$   
 C. 3s  $\uparrow$  3p  $\uparrow\downarrow$   $\uparrow\downarrow$   $\uparrow\downarrow$   
 D. 3s  $\uparrow$  3p  $\uparrow\downarrow$   $\uparrow\downarrow$   $\uparrow\uparrow$

13. At room temperature, sodium reacts with sulfur hexafluoride to produce sodium sulfide and sodium fluoride.



Which of the following statements correctly describes the information provided by this balanced chemical equation?

- A. The products have a larger mass than the reactants.
  - B. The products have a smaller mass than the reactants.
  - C. The number of moles of products is larger than the number of moles of reactants.
  - D. The number of moles of products is smaller than the number of moles of reactants.
14. Deuterium ( $^2\text{H}$ ) is an isotope of hydrogen. A scientist finds that both of these reactions occur.

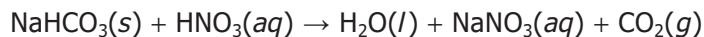


Which of the following statements best explains the scientist's findings?

- A. Isotopes have different chemical properties.
  - B. Isotopes have similar chemical properties.
  - C. Isotopes have different physical properties.
  - D. Isotopes have similar physical properties.
15. The sulfide ion ( $\text{S}^{2-}$ ) has an ionic radius of 184 pm ( $1 \text{ pm} = 10^{-12} \text{ m}$ ). Use the periodic table to determine the most likely ionic radii for the oxide ion ( $\text{O}^{2-}$ ) and the selenide ion ( $\text{Se}^{2-}$ ).
- A.  $\text{O}^{2-} = 140 \text{ pm}$  and  $\text{Se}^{2-} = 198 \text{ pm}$
  - B.  $\text{O}^{2-} = 198 \text{ pm}$  and  $\text{Se}^{2-} = 140 \text{ pm}$
  - C.  $\text{O}^{2-} = 198 \text{ pm}$  and  $\text{Se}^{2-} = 226 \text{ pm}$
  - D.  $\text{O}^{2-} = 226 \text{ pm}$  and  $\text{Se}^{2-} = 198 \text{ pm}$
16. Which of the following representations is a structural formula?

- A. O
- B. HO
- C.  $\text{H}_2\text{O}_2$
- D.  $\text{H} - \text{O} - \text{O} - \text{H}$

17. Sodium bicarbonate reacts with nitric acid to produce water, sodium nitrate, and carbon dioxide.



Paul carefully adds 7.50 g of  $\text{NaHCO}_3$  to an excess of  $\text{HNO}_3$ . The reaction produces 3.25 g of  $\text{CO}_2$ . What is the percent yield of  $\text{CO}_2$  in this reaction?

- A. 82.7%
  - B. 76.5%
  - C. 56.7%
  - D. 43.3%
18. What is the shape of the atomic orbital occupied by the outermost electron in a ground-state Cs atom?
- A. Cylinder
  - B. Dumbbell
  - C. Oval
  - D. Sphere

19. Chemists generate hydrogen gas using this exothermic reaction.



Assuming that the reaction is at equilibrium, which of the following changes will increase the amount of  $\text{H}_2$ ?

- A. Removing  $\text{CO}_2$  from the reaction
  - B. Removing CO from the reaction
  - C. Increasing the temperature
  - D. Adding a catalyst
20. A biochemistry student prepares a saline solution containing the same concentration of NaCl as that of normal human blood. The student adds 2.25 g of NaCl to 250.0 g of sterile water. What is the percent by mass of NaCl in the saline solution?
- A. 0.884%
  - B. 0.892%
  - C. 0.900%
  - D. 0.908%
21. Real gases best imitate the behavior of ideal gases under which of the following conditions?
- A. 100 K and 1 atm
  - B. 100 K and 300 atm
  - C. 1,000 K and 1 atm
  - D. 1,000 K and 300 atm

22. Use the data in this table to determine which of the following reactions produces a precipitate.

<b>Key</b> S = soluble I = insoluble
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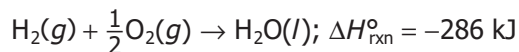
<b>Solubilities of Ionic Compounds in H<sub>2</sub>O at 25°C</b>					
	Br <sup>-</sup>	Cl <sup>-</sup>	NO <sub>3</sub> <sup>-</sup>	OH <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>
Cu <sup>2+</sup>	S	S	S	I	S
K <sup>+</sup>	S	S	S	S	S
Li <sup>+</sup>	S	S	S	S	S
Mg <sup>2+</sup>	S	S	S	I	S
Na <sup>+</sup>	S	S	S	S	S

- A.  $\text{CuSO}_4 + \text{MgBr}_2 \rightarrow \text{CuBr}_2 + \text{MgSO}_4$   
B.  $\text{CuSO}_4 + 2\text{KNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + \text{K}_2\text{SO}_4$   
C.  $\text{CuSO}_4 + 2\text{LiCl} \rightarrow \text{CuCl}_2 + \text{Li}_2\text{SO}_4$   
D.  $\text{CuSO}_4 + 2\text{NaOH} \rightarrow \text{Cu}(\text{OH})_2 + \text{Na}_2\text{SO}_4$
23. At 22°C, the air pressure in a car tire is 1,293 torr. Convert this pressure to atmospheres (atm).
- A. 12.76 atm  
B. 5.262 atm  
C. 1.701 atm  
D. 1.293 atm
24. Use the valence-shell electron-pair repulsion (VSEPR) theory to determine the molecular geometry of SCl<sub>2</sub>.
- A. Trigonal planar  
B. Tetrahedral  
C. Linear  
D. Bent
25. The boiling point of Liquid X is 56.3°C. Sylvia heats 2.28 g of Liquid X until it completely vaporizes. She collects all the gas in a 750.0 mL vessel. The pressure of the gas is 1.41 atm at 56.3°C. The molar mass of Liquid X is:
- A. 9.97 g/mol.  
B. 22.3 g/mol.  
C. 58.3 g/mol.  
D. 121 g/mol.



26. Anne completely fills the fuel tank of her car with a mixture of gasoline and ethanol ( $\text{C}_2\text{H}_5\text{OH}$ ). When filled, the fuel tank contains 4,482 g of  $\text{C}_2\text{H}_5\text{OH}$ . How many moles of  $\text{C}_2\text{H}_5\text{OH}$  are in the fuel tank?
- A. 77.17 mol
  - B. 97.29 mol
  - C. 131.6 mol
  - D. 149.1 mol

27. This equation shows the heat of reaction ( $\Delta H_{\text{rxn}}^\circ$ ) for the formation of 1.00 mol of water from the reaction of hydrogen and oxygen.



What is the minimum amount of energy required to produce 1.00 mol of  $\text{O}_2$  through the decomposition of  $\text{H}_2\text{O}$ ?

- A. 572 kJ
  - B. 286 kJ
  - C. -286 kJ
  - D. -572 kJ
28. A student needs 250.0 mL of aqueous 2.50 M hydrochloric acid for an experiment. The student has 150.0 mL of 6.00 M  $\text{HCl}(aq)$ . Which of the following procedures can the student use to prepare the required solution?
- A. Adding 3.600 mL of 6.00 M  $\text{HCl}(aq)$  to approximately 225 mL of water and diluting to 250.0 mL with water
  - B. Adding 16.67 mL of 6.00 M  $\text{HCl}(aq)$  to approximately 200 mL of water and diluting to 250.0 mL with water
  - C. Adding 62.50 mL of 6.00 M  $\text{HCl}(aq)$  to approximately 175 mL of water and diluting to 250.0 mL with water
  - D. Adding 104.2 mL of 6.00 M  $\text{HCl}(aq)$  to approximately 125 mL of water and diluting to 250.0 mL with water
29. Which of the following balanced chemical equations is best classified as a single replacement reaction?
- A.  $2\text{K}(s) + \text{Br}_2(l) \rightarrow 2\text{KBr}(s)$
  - B.  $2\text{HgO}(s) \rightarrow 2\text{Hg}(l) + \text{O}_2(g)$
  - C.  $\text{Zn}(s) + \text{CuSO}_4(aq) \rightarrow \text{ZnSO}_4(aq) + \text{Cu}(s)$
  - D.  $\text{NaCl}(aq) + \text{AgNO}_3(aq) \rightarrow \text{NaNO}_3(aq) + \text{AgCl}(s)$

30. A chemist compresses a 1.5 L sample of carbon dioxide gas at 1.2 atm to a final volume of 0.75 L at a constant temperature. What is the final pressure of the gas?
- A. 0.60 atm  
B. 0.94 atm  
C. 1.7 atm  
D. 2.4 atm
31. If a student adds 2.00 g of NaOH to 250.0 mL of pure water, which of the following values is closest to the resulting pOH of the water?
- A. 0.7  
B. 3.7  
C. 10.3  
D. 13.3

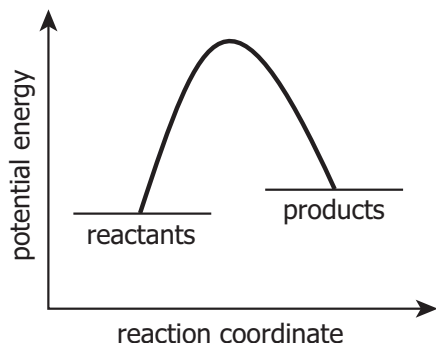
32. Element Q has 3 isotopes with the relative abundances shown in this table.

Isotope	Atomic mass (amu)	Relative abundance (%)
1	53.00	40.00
2	56.60	35.00
3	58.90	25.00

What is the weighted average atomic mass of Element Q?

- A. 55.74 amu  
B. 55.97 amu  
C. 56.17 amu  
D. 56.62 amu
33. At 900°C, beryllium reacts with nitrogen to produce beryllium nitride.
- $$3\text{Be}(s) + \text{N}_2(g) \rightarrow \text{Be}_3\text{N}_2(s)$$
- Dr. Jia combines 55.90 g of Be with 23.75 g of N<sub>2</sub>. What is the maximum mass of Be<sub>3</sub>N<sub>2</sub> that the reaction can produce?
- A. 32.15 g  
B. 46.67 g  
C. 79.65 g  
D. 113.8 g

34. This diagram shows the progress of a chemical reaction from reactants to products.



Which of the following statements most accurately describes this chemical reaction?

- A. The reaction has an enthalpy change that is endothermic.
  - B. The reaction has a 2-step mechanism with a stable intermediate.
  - C. The products have a lower potential energy than the reactants.
  - D. The activated complex of the reaction has a lower potential energy than the products.
35. A scientist measures the density of iridium (Ir) metal as  $21.52 \text{ g/cm}^3$ . The actual density of Ir metal is  $22.65 \text{ g/cm}^3$ . What is the percent error in the scientist's measurement?
- A. 0.04989%
  - B. 0.05251%
  - C. 4.989%
  - D. 5.251%
36. In a famous experiment, scientists bombarded a very thin gold (Au) foil with positively charged alpha particles. They found that most of the alpha particles passed right through the Au foil. However, a few of the alpha particles were deflected or bounced back toward the source. How did these scientists explain their results?
- A. Negative charges are spread throughout the atom.
  - B. Negative charges are located in the tiny nucleus of the atom.
  - C. Positive charges are spread throughout the atom.
  - D. Positive charges are located in the tiny nucleus of the atom.

- 37.** A reaction occurs between 2 gases in a sealed vessel. The rate of the reaction increases as the temperature of the system increases. According to the collision theory of chemical kinetics, which of the following statements best explains this rate increase?
- A.** The concentration of the catalyst increases.
  - B.** The kinetic energy of the reactants increases.
  - C.** The activation energy for the reaction decreases.
  - D.** The frequency of collisions between reactant molecules decreases.
- 38.** Which of the following properties of a solid aluminum cube is different on Earth than it is on the Moon?
- A.** Weight
  - B.** Volume
  - C.** Mass
  - D.** Density

# International Subject Test— Chemistry Practice Test

## Part 2 Answer Key

The following table contains the question number and the correct answer (Key) for each question in Part 2 of this PDF file.

1	D
2	B
3	D
4	C
5	A
6	B
7	A
8	B
9	C
10	D
11	C
12	B
13	D
14	B
15	A
16	D
17	A
18	D
19	A

20	B
21	C
22	D
23	C
24	D
25	C
26	B
27	A
28	D
29	C
30	D
31	A
32	A
33	B
34	A
35	C
36	D
37	B
38	A