1) Which substance acts as the base in the reaction: \( \text{NH}_3 \text{(aq)} + \text{HNO}_3 \text{(aq)} \rightleftharpoons \text{NH}_4\text{?}(aq) + \text{NO}_3\text{?}(aq) \)

A  NH3  
B  HNO3  
C  NH4?  
D  NO3?

ItemID A2KC.1130896  
Correct A  
Standard: 9-12CH 5.b

2) In the reaction \( \text{H}_3\text{O}? + \text{C}_2\text{H}_3\text{O}_2? \rightarrow \text{HC}_2\text{H}_3\text{O}_2 + \text{H}_2\text{O} \), which compound acts as the acid?

A  H3O?  
B  C2H3O2?  
C  HC2H3O2  
D  H2O

ItemID A2KC.1127534  
Correct A  
Standard: 9-12CH 5.b

3) In the reaction \( \text{H}_3\text{O}? + \text{CO}_3\text{?} \rightarrow \text{HCO}_3? + \text{H}_2\text{O} \), which compound acts as the base?

A  H3O?  
B  CO3??  
C  HCO3?  
D  H2O

ItemID A2KC.1127532  
Correct B  
Standard: 9-12CH 5.b

4) Mr. Baker, the chemistry teacher, plans to demonstrate a reaction between a weak acid and a strong base in his class. Which acid and base could he use to demonstrate this reaction?

A  acetic acid and sodium hydroxide  
B  sulfuric acid and sodium hydroxide  
C  acetic acid and ammonium hydroxide  
D  sulfuric acid and ammonium hydroxide

ItemID A2K.1021919  
Correct A  
Standard: 9-12CH 5.c

5) The equation below shows how an unknown compound dissociates when dissolved in water.

\[ \text{QH} \rightleftharpoons \text{H}^+ + \text{Q}^- \]

If this compound is 99.9% dissociated in solution, how would it be classified?

A  as a strong base  
B  as a strong acid  
C  as a weak base  
D  as a weak acid

ItemID A2K.1023508  
Correct B  
Standard: 9-12CH 5.c
6) The percentages of dissociation of four acids are listed below.

Acid P is 0.60% dissociated.
Acid Q is 4.15% dissociated.
Acid R is 12.55% dissociated.
Acid S is 71.55% dissociated.

Which comparison of the strengths of the acids is correct?

A  Q is a stronger acid than R.
B  R is a stronger acid than S.
C  R is a weaker acid than Q.
D  P is a weaker acid than Q.

ItemID: A2K.1023509  
Correct: D  
Standard: 9-12CH 5.c

7) The label on a bottle indicates that the substance inside has a pH of 13. This tells you that the substance is

A  neutral.
B  strongly acidic.
C  mildly basic.
D  strongly basic.

ItemID: DD-HOLT.1040354  
Correct: D  
Standard: 9-12CH 5.d

8) Sean is measuring a solution’s pH. What is the range of the pH scale from the lowest to the highest possible values?

A  1 to 7
B  0 to 10
C  1 to 13
D  0 to 14

ItemID: A2K.1077568  
Correct: D  
Standard: 9-12CH 5.d

9) A solution that is mildly acidic would have a pH of approximately

A  2.  
B  4.  
C  6.  
D  8.

ItemID: DD-HOLT.1040352  
Correct: C  
Standard: 9-12CH 5.d

10) Which statement correctly describes the change in molecular motion as water undergoes a change of phase?

A  Molecular motion increases as liquid water becomes ice.
B  Molecular motion increases as liquid water becomes water vapor.
C  Molecular motion decreases as liquid water becomes water vapor.
D  Molecular motion decreases as ice becomes liquid water.

ItemID: A2K.1022577  
Correct: B  
Standard: 9-12CH 7.a

11) Temperature is

A  associated with the sensation of hot and cold.
B  proportional to the average kinetic energy of molecules.
C  measured with thermometers.
D  All of the above

ItemID: DD-HOLT.1040414  
Correct: D  
Standard: 9-12CH 7.a
12) In which sequence are the materials arranged in order of DECREASING average molecular velocity?

A  air, iron, oil
B  air, oil, iron
C  iron, air, oil
D  oil, iron, air

ItemID A2K.1022574
Correct B
Standard: 9-12CH 7.a

13) Which graph represents a chemical reaction that absorbs energy?

A

B

C

D

ItemID A2K.1114996
Correct B
Standard: 9-12CH 7.a

14) Which describes an endothermic process?

A  an ice cube melting in a glass of warm soda
B  natural gas burning in the furnace of a house
C  dissolving of CaCl2 in water, making the solution warmer
D  a firecracker exploding

ItemID A2KC.1130936
Correct A
Standard: 9-12CH 7.b

15) Which describes an exothermic process?

A  dissolving KNO3 in water, making the solution colder
B  the combustion of gasoline in a car engine
C  dry ice subliming, CO2 (s) + energy \(\rightarrow\) CO2 (g)
D  your body in a hot Jacuzzi spa

ItemID A2KC.1130935
Correct B
Standard: 9-12CH 7.b
16) How is the energy of molecules of steam at 100°C different from the energy of liquid water molecules at 100°C?

A Water molecules of steam have less kinetic energy.
B Water molecules of steam have more kinetic energy.
C Water molecules of steam have less potential energy.
D Water molecules of steam have more potential energy.

ItemID: A2K.1183745
Correct: D
Standard: 9-12CH 7.c

17) People’s bodies react to high temperature by perspiring. Why does perspiring make people feel cooler?

A Perspiring creates a liquid barrier between the skin and the warm air.
B Perspiring causes cool water vapor from the air to condense on the skin.
C Perspiring coats the skin with moisture that is cooler than the surrounding air.
D Perspiring produces moisture that absorbs heat from the skin as it evaporates.

ItemID: A2K.1022624
Correct: D
Standard: 9-12CH 7.c

18) The ice cube in the glass shown below is melting.

How is energy being transferred in the glass?

A The ice cube releases heat to the surroundings.
B The ice cube releases cold to the surroundings.
C The ice cube absorbs heat from the surroundings.
D The ice cube absorbs cold from the surroundings.

ItemID: A2K.1018491
Correct: C
Standard: 9-12CH 7.c
19) A solid material at 0°C is heated at a constant rate, and its temperature is measured at regular intervals. The graph below shows how the temperature of the material varies with time.

![Graph showing temperature variation with time]

Which statement is a correct interpretation of the graph?

A  Solid and liquid are present during interval A.
B  A phase change takes place during interval B.
C  The latent heat of fusion accounts for the energy absorbed during interval C.
D  No heat is absorbed during interval D.

ItemID A2K.1022627
Correct B
Standard: 9-12CH 7.d

20) Naomi is investigating the properties of a solid material. It takes 120 joules to raise the temperature of 10 grams of the material by 5 degrees. What is the specific heat of the material?

A  0.4 J/°C/g
B  2.4 J/°C/g
C  8.0 J/°C/g
D  60 J/°C/g

ItemID A2K.1022385
Correct B
Standard: 9-12CH 7.d

21) What is the total heat required to raise the temperature of 500 g of water from 25°C to 100°C? (The specific heat of water is 4.18 J/°C/g.)

A  8,360 J
B  13,933 J
C  156,750 J
D  261,250 J

ItemID A2K.1022383
Correct C
Standard: 9-12CH 7.d

22) The equation below shows the combustion of methane (CH₄) to produce carbon dioxide (CO₂) and water (H₂O).

\[ \text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} \]

How does the rate at which H₂O is produced compare with the rate at which CH₄ is consumed?

A  H₂O is produced half as fast as CH₄ is consumed.
B  H₂O is produced equally as fast as CH₄ is consumed.
C  H₂O is produced twice as fast as CH₄ is consumed.
D  H₂O is produced four times as fast as CH₄ is consumed.

ItemID A2K.1018498
Correct C
Standard: 9-12CH 8.a
23) Which unit could be used to express the rate of a reaction?

- moles/liter
- seconds
- seconds/mole
- liters
- moles of product
- moles of reactant
- moles of reactant
- moles of product

ItemID A2K.1018497
Correct A
Standard: 9-12CH 8.a

24) What could you do to make yeast dough rise more slowly?

- Add more yeast to the mixture.
- Knead the dough more vigorously.
- Add mold spores to the dough.
- Reduce the temperature.

ItemID DD-HOLT.1040327
Correct D
Standard: 9-12CH 8.a, 9-12CH 8.b

25) What are two reasons that an increase in temperature causes an increase in reaction rate?

- Activation energy increases and concentration increases.
- Concentration increases and the number of collisions increases.
- Kinetic energy of molecules increases and activation energy increases.
- The number of collisions increases and kinetic energy of molecules increases.

ItemID A2K.1057055
Correct D
Standard: 9-12CH 8.b

26) A chemical reaction releases heat energy. Which BEST agrees with this information?

- Removing heat from this reaction will have little effect.
- Adding heat to this reaction will speed up the reverse rate.
- Adding heat to this reaction will speed up the forward rate.
- Removing heat from this reaction will speed up the reverse rate.

ItemID A2K.1114811
Correct B
Standard: 9-12CH 8.b

27) The equation for the production of sulfur trioxide (SO₃) from sulfur dioxide (SO₂) and oxygen (O₂) is shown below.

$$2\text{SO}_2(g) + \text{O}_2(g) \rightarrow 2\text{SO}_3(g)$$

Why does increasing the pressure on the reacting gases increase the rate of this reaction?

- Molecules collide with less kinetic energy.
- The number of collisions between molecules increases.
- Collisions between molecules occur at different angles.
- The molecules slow down and have more time to react when they collide.

ItemID A2K.1057054
Correct B
Standard: 9-12CH 8.b

28) An enzyme is a special kind of catalyst that works to

- speed up a specific biochemical reaction.
- break down chemical elements.
- slow down a chemical reaction.
- maintain the correct temperature for a reaction.

ItemID DD-HOLT.1040328
Correct A
Standard: 9-12CH 8.c
29) Which potential energy diagram BEST shows how a catalyst affects a chemical reaction?

A

B

C

D

30) Under normal conditions, hydrogen peroxide decomposes very slowly to produce oxygen and water. In the presence of manganese dioxide, the reaction proceeds at a much greater rate. The manganese dioxide can be recovered and used to speed the decomposition of still more hydrogen peroxide. How does manganese dioxide increase the rate of this reaction?

A by increasing the entropy change of the reaction
B by making the reaction exothermic instead of endothermic
C by providing a different route with a lower activation energy
D by increasing the energy difference between products and reactants

31) Le Châtelier’s principle states that increasing temperature favors a reaction that

A releases energy as heat.
B requires energy as heat.
C involves a chemical catalyst.
D involves an enzyme.

32) Increasing the concentration of one substance in an equilibrium reaction favors the reaction that

A absorbs energy as heat.
B releases energy as heat.
C produces less of that substance.
D produces more of that substance.
33) The chemical reaction below is a reversible reaction.

\[ 2\text{H}_2\text{S} \rightleftharpoons 2\text{H}_2 + \text{S}_2 \]

If the \(\text{H}_2\text{S}\) is removed from the system, what will occur?

A The reaction will proceed to the right, causing a decrease in the formation of \(\text{S}_2\).
B The reaction will proceed to the left, causing an increase in the formation of \(\text{H}_2\).
C The reaction will proceed to the right, causing a decrease in the formation of \(\text{H}_2\text{S}\).
D The reaction will proceed to the left, causing an increase in the formation of \(\text{H}_2\text{S}\).

ItemID A2K.1022232
Correct D
Standard: 9-12CH 9.a

34) What is the relationship between chemical equilibrium and the rates of forward and reverse reaction?

A In equilibrium, the forward reaction rate must be greater than the reverse reaction rate.
B In equilibrium, the forward reaction rate must be less than the reverse reaction rate.
C In equilibrium, the forward and reverse reaction rates must be equal.
D In equilibrium, both forward and reverse reactions must stop.

ItemID DD-HOLT.1040330
Correct C
Standard: 9-12CH 9.b

35) When a chemical reaction and its reverse are occurring at the same time and at the same rate, the reaction has achieved

A displacement.
B equilibrium.
C imbalance.
D decomposition.

ItemID DD-HOLT.1040329
Correct B
Standard: 9-12CH 9.b

36) The graph below shows how the reaction rate changes during the time period immediately after two reactants are combined.

At which time on the graph is the system CLOSEST to equilibrium?

A Time 1
B Time 2
C Time 3
D Time 4

ItemID A2K.1018475
Correct D
Standard: 9-12CH 9.b
37) Alcohols are organic compounds that contain

A  carbon and oxygen only.
B  carbon and hydrogen only.
C  carbon, oxygen, and hydrogen.
D  carbon, nitrogen, and hydrogen.

ItemID DD-HOLT.1040312  
Correct C  
Standard: 9-12CH 10.a

38) Polymers are large organic molecules that are made of

A  cations.
B  anions.
C  carbon and oxygen only.
D  repeating units.

ItemID DD-HOLT.1040313  
Correct D  
Standard: 9-12CH 10.a

39) Alkanes are hydrocarbons that contain

A  single covalent bonds only.
B  single or double covalent bonds.
C  carbon and oxygen only.
D  carbon, hydrogen, and oxygen.

ItemID DD-HOLT.1040311  
Correct A  
Standard: 9-12CH 10.a

40) A carbon atom can bond to four other atoms because it has

A  four different cations.
B  four valence electrons.
C  two inner energy levels.
D  no protons in its nucleus.

ItemID DD-HOLT.1040309  
Correct B  
Standard: 9-12CH 10.b

41) The simplest organic compound is

A  table sugar.
B  aspirin.
C  salt.
D  methane.

ItemID DD-HOLT.1040310  
Correct D  
Standard: 9-12CH 10.b

42) Diamond and graphite are both elemental forms of carbon. Diamond has a tetrahedral arrangement and is very hard. Graphite has a trigonal planar arrangement, with layers that can slide over each other. Which explains the differences in the properties of these two forms?

A  Diamond has triple bonds and graphite single bonds.
B  Diamond has triple bonds and graphite double bonds.
C  Diamond has double bonds and graphite single bonds.
D  Diamond has single bonds and graphite double bonds.

ItemID A2KC.1130964  
Correct D  
Standard: 9-12CH 10.a

43) Which polymer is made up of amino acid subunits?

A  crystals
B  hydrocarbons
C  proteins
D  starches

ItemID A2K.1018507  
Correct C  
Standard: 9-12CH 10.b
44) Where is the information stored that determines the structure of the many different protein molecules essential to a living organism?

A  ATP  
B  DNA  
C  enzymes  
D  ribosomes  

ItemID A2K.1016888  
Correct B  
Standard: 9-12CH 10.c

45) Proteins can be referred to as polypeptides. How are peptides related to amino acids?

A  Peptides are the monomers, amino acids are the linkages between them.  
B  Amino acids are the monomers, peptides are the linkages between them.  
C  Amino acids and peptides are different names for the same structures.  
D  Amino acids are the side groups, peptides the main chain of a protein.  

ItemID A2KC.1130968  
Correct B  
Standard: 9-12CH 11.c

46) A sufficiently large nucleus is unstable and has a tendency to show spontaneous radioactive emissions. What is the reason for these spontaneous emissions?

A  The nuclear force between the protons overcomes the electrostatic force of repulsion.  
B  The electrostatic force of repulsion between the protons overcomes the nuclear force.  
C  The electrostatic force of repulsion between the protons reduces and becomes equal to the nuclear force.  
D  The nuclear force between the protons reduces and becomes equal to the electrostatic force of repulsion.  

ItemID A2K.1022671  
Correct B  
Standard: 9-12CH 11.c

47) Radium-226 is an unstable isotope of radium. Which statement describes what happens to the radium-226 atoms?

A  The atoms undergo nuclear fusion.  
B  The atoms undergo radioactive decay.  
C  The atoms remain unstable until other atoms are available to react with.  
D  The atoms absorb energy from their surroundings to become more stable.  

ItemID A2K.1022672  
Correct B  
Standard: 9-12CH 11.c
48) C\textsubscript{14} and C\textsubscript{12} are two isotopes of carbon. C\textsubscript{14} exhibits spontaneous nuclear decay, but C\textsubscript{12} does not. Which of these explains the reason for this difference in their behavior?

A  C\textsubscript{14} has an unstable nucleus because C\textsubscript{14} has more neutrons than C\textsubscript{12}.
B  C\textsubscript{14} has an unstable nucleus because C\textsubscript{14} has more protons than C\textsubscript{12}.
C  C\textsubscript{14} has a stable nucleus because C\textsubscript{14} has more neutrons than C\textsubscript{12}.
D  C\textsubscript{14} has a stable nucleus because C\textsubscript{14} has more protons than C\textsubscript{12}.

51) A scientist has a radioactive substance in a lead container. What does the substance MOST LIKELY do?

A  spontaneously explode
B  disturb normal electric fields
C  randomly change from solid to liquid
D  emit high-energy particles and waves

52) Small radioactive sources that are present in smoke detectors release

A  alpha particles.
B  beta particles.
C  gamma rays.
D  neutrons.
53) Radioactive tracers are short-lived

A  drugs.
B  isotopes.
C  tumors.
D  rays.

ItemID: DD-HOLT.1040386
Correct: B
Standard: 9-12CH 11.e

54) To treat certain brain tumors, doctors can use small beams of _____ that are focused to kill only the tumor cells.

A  X rays
B  beta rays
C  alpha rays
D  gamma rays

ItemID: DD-HOLT.1040387
Correct: D
Standard: 9-12CH 11.e
### Formulas

**Ideal Gas Law:** \( PV = nRT \)

**Combined Gas Law:** \( \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \)

**Pressure Formula:** \( P = \frac{F}{A} \)

**Mass-Energy Formula:** \( E = mc^2 \)

**Calorimetric Formulas –**

**No Phase Change:** \( Q = m(\Delta T)C_p \)

**Latent Heat of Fusion:** \( Q = m\Delta H_{\text{fus}} \)

**Latent Heat of Vaporization:** \( Q = m\Delta H_{\text{vap}} \)

### Constants

**Volume of Ideal Gas at STP:** \( 22.4 \text{ L mol}^{-1} \)

**Speed of Light in a Vacuum:** \( c = 3.00 \times 10^8 \text{ m s}^{-1} \)

**Specific Heat of Water:** \( C_p(\text{H}_2\text{O}) = 1.00 \frac{\text{cal}}{\text{g} \; ^\circ\text{C}} = 4.18 \frac{\text{J}}{\text{g} \; ^\circ\text{C}} \)

**Latent Heat of Fusion of Water:** \( \Delta H_{\text{fus}}(\text{H}_2\text{O}) = 80 \frac{\text{cal}}{\text{g}} = 334 \frac{\text{J}}{\text{g}} \)

**Latent Heat of Vaporization of Water:** \( \Delta H_{\text{vap}}(\text{H}_2\text{O}) = 540 \frac{\text{cal}}{\text{g}} = 2260 \frac{\text{J}}{\text{g}} \)

### Unit Conversions

**Calorie-Joule Conversion:** \( 1 \text{ cal} = 4.184 \text{ J} \)

**Absolute Temperature Conversion:** \( K = ^\circ\text{C} + 273 \)

**Pressure Conversions:** \( 1 \text{ atm} = 760 \text{ mm Hg} = 760 \text{ Torr} = 101.325 \text{ kPa} = 14.7 \frac{\text{lbs}}{\text{in.}^2} = 29.92 \text{ in. Hg} \)
### Periodic Table of the Elements

#### Chemistry Reference Sheet

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* If this number is in parentheses, then it refers to the atomic mass of the most stable isotope.