

Chem 10 Chapter 3

Matter and Energy

Practice and End of Chapter Questions

Worked solutions at the end

Use your course periodic table and a calculator as needed. Show the setup, include units, and round at the end. Question numbers match the numbers in the solutions. Use heading navigation to move between sections.

Reference values: 1 cal = 4.184 J; 1 Cal = 1000 cal; 1 kWh = 3.6×10^6 J. Specific heat capacities in J/(g °C): lead 0.128, gold 0.128, silver 0.235, copper 0.385, iron 0.449, aluminum 0.903, ethanol 2.42, water 4.184. Use a value stated in a question when one is supplied.

Practice Questions

Question 1

A solid form of matter in which there is long range repeating order is called _____.

- A) crystalline
- B) fixed
- C) amorphous
- D) rigid
- E) none of the above

Question 2

Which among the following statements is FALSE?

- A) A solid has a definite shape and a definite volume.
- B) Both solids and liquids are incompressible while gases are compressible.
- C) A liquid has a definite volume; but it has no definite shape.
- D) A gas has neither definite volume nor definite shape.
- E) none of the above

Question 3

Which of the following is an example of a crystalline solid that shows an arrangement of long-range, repeating order?

- A) rubber
- B) salt
- C) plastic
- D) glass
- E) none of the above

Question 4

Which of the following items is a pure substance?

- A) seawater
- B) ice
- C) air
- D) brass
- E) none of the above

Question 5

How would you classify raisin bran?

- A) pure substance-compound
- B) mixture-heterogeneous
- C) pure substance-element
- D) mixture-homogeneous
- E) none of the above

Question 6

Physical properties are:

- A) those that a substance displays only through changing its composition.
- B) those that cause atoms and molecules to change.
- C) identical for all solid matter.
- D) those that a substance displays without changing its composition.
- E) none of the above

Question 7

When methane is burned with oxygen the products are carbon dioxide and water. If you produce 36 grams of water and 44 grams of carbon dioxide from 16 grams of methane, how many grams of oxygen were needed for the reaction?

- A) 64
- B) 32
- C) 96
- D) 80
- E) none of the above

Question 8

Which type of energy is associated with motion?

- A) kinetic
- B) chemical
- C) electrical
- D) potential
- E) none of the above

Question 9

Which type of energy is associated with position?

- A) chemical
- B) kinetic
- C) potential
- D) electrical
- E) none of the above

Question 10

How many kilojoules are there in 95.0 Calories? 1 cal = 4.18 J (remember the distinction between cal and Cal)

- A) 397
- B) 2.27×10^7
- C) 3.97×10^{-4}
- D) 22.7
- E) none of the above

Question 11

If a particular process is endothermic, the reverse process must be a (an):

- A) isothermal process.
- B) chemical change.
- C) endothermic process.
- D) exothermic process.
- E) none of the above

Question 12

Which of the following is NOT true?

- A) The kelvin temperature scale avoids use of negative numbers.
- B) The degree "symbol" is not used with the kelvin scale.
- C) Water boils at the same temperature value on both the kelvin and Celsius scales.
- D) A kelvin degree is the same size as a Celsius degree.
- E) none of the above

Question 13

What is the value of 27°C on the kelvin temperature scale?

- A) 246
- B) 273
- C) 81
- D) 300
- E) none of the above

Question 14

How much heat (kJ) is needed to raise the temperature of 100.0 grams of water from 25.0°C to 50.0°C?

- A) 1.05
- B) 10450
- C) 10.5
- D) 0.598
- E) none of the above

Question 15

A 15.0 gram lead ball at 25.0°C was heated with 40.5 joules of heat. Given the specific heat of lead is 0.128 J/g·°C, what is the final temperature of the lead?

- A) 77.8°C
- B) 0.844°C
- C) 21.1°C
- D) 46.1°C
- E) none of the above

Question 16

From the following list of substances and specific heat capacities, choose the one that will have the lowest temperature after absorbing 100.0 kJ of heat. Assume identical masses of each substance start at the same initial temperature.

- A) copper-0.385 J/g·°C
- B) water-4.18 J/g·°C
- C) lead-0.128 J/g·°C
- D) ethanol-2.42 J/g·°C
- E) not enough information

Question 17

When 49.5 J of heat was transferred to 7.3 g iron at 22°C, the temperature of iron increases to 37°C. What is the specific heat of iron in J/g·°C?

- A) 24
- B) 4.5
- C) 0.45
- D) 2.2
- E) none of the above

End of Chapter Questions

Question 18

The equation $^{\circ}\text{C} = (^{\circ}\text{F} - 32)/1.8$ converts Fahrenheit temperature to Celsius temperature. Use algebra to change the equation to convert Celsius temperature to Fahrenheit temperature.

Question 19

Classify each pure substance as an element or a compound.

- (a) aluminum
- (b) sulfur
- (c) methane
- (d) acetone

Question 20

Classify each mixture as homogeneous or heterogeneous.

- (a) coffee
- (b) chocolate sundae
- (c) apple juice
- (d) gasoline

Question 21

Classify each substance as a pure substance or a mixture. If pure, classify it as an element or a compound. If a mixture, classify it as homogeneous or heterogeneous.

- (a) helium gas
- (b) clean air
- (c) rocky road ice cream
- (d) concrete

Question 22

Classify each property as physical or chemical.

- (a) the tendency of silver to tarnish
- (b) the shine of chrome
- (c) the color of gold
- (d) the flammability of propane gas

Question 23

Classify each change as physical or chemical.

- (a) A balloon filled with hydrogen gas explodes upon contact with a spark.
- (b) Liquid propane in a barbecue evaporates away because someone left the valve open.
- (c) Liquid propane in a barbecue ignites upon contact with a spark.
- (d) Copper metal turns green on exposure to air and water.

Question 24

An automobile gasoline tank holds 42 kg of gasoline. When the gasoline burns, 168 kg of oxygen are consumed and carbon dioxide and water are produced. What total combined mass of carbon dioxide and water is produced?

Question 25

Are these data on chemical changes consistent with the law of conservation of mass?

- (a) A 7.5-g sample of hydrogen gas completely reacts with 60.0 g of oxygen gas to form 67.5 g of water.
- (b) A 60.5-g sample of gasoline completely reacts with 243 g of oxygen to form 206 g of carbon dioxide and 88 g of water.

Question 26

In a butane lighter, 9.7 g of butane combine with 34.7 g of oxygen to form 29.3 g of carbon dioxide and how many grams of water?

Question 27

Perform each conversion.

- (a) 588 cal to joules
- (b) 17.4 J to Calories
- (c) 134 kJ to Calories
- (d) 56.2 Cal to joules

Question 28

Perform each conversion.

- (a) 25 kWh to joules
- (b) 249 cal to Calories
- (c) 113 cal to kilowatt-hours
- (d) 44 kJ to calories

Question 29

An adult eats food whose nutritional energy totals approximately 2.2×10^3 Cal per day. The adult burns 2.0×10^3 Cal per day. How much excess nutritional energy, in kilojoules, does the adult consume per day? If 1 lb of fat is stored for every 14.6×10^3 kJ of excess nutritional energy consumed, how long will it take this person to gain 1 lb?

Question 30

A common type of handwarmer contains iron powder that reacts with oxygen to form an oxide of iron. As soon as the handwarmer is exposed to air, the reaction begins and heat is emitted. Is the reaction exothermic or endothermic? Draw an energy diagram showing the relative energies of the reactants and products.

Question 31

Classify each process as exothermic or endothermic.

- (a) gasoline burning in a car
- (b) isopropyl alcohol evaporating from skin
- (c) water condensing as dew during the night

Question 32

Perform each temperature conversion.

- (a) 212°F to Celsius (temperature of boiling water)
- (b) 77 K to Fahrenheit (temperature of liquid nitrogen)
- (c) 25°C to kelvins (room temperature)
- (d) 98.6°F to kelvins (body temperature)

Question 33

The temperature in the South Pole during the Antarctic winter is so cold that planes cannot land or take off, effectively isolating the inhabitants of the South Pole base for the winter. The average daily temperature at the South Pole in July is -59.7°C . Convert this temperature to degrees Fahrenheit.

Question 34

Calculate the amount of heat required to raise the temperature of a 65-g sample of water from 32°C to 65°C .

Question 35

An iron nail with a mass of 12 g absorbs 15 J of heat. If the nail was initially at 28°C , what is its final temperature?

Question 36

Calculate the temperature change that occurs when 248 cal of heat are added to 24 g of water.

Question 37

An unknown metal with a mass of 28 g absorbs 58 J of heat. Its temperature rises from 31.1 °C to 39.9 °C. Calculate the specific heat capacity of the metal and identify it using the reference values at the beginning of this packet.

Question 38

When 56 J of heat are added to 11 g of a liquid, its temperature rises from 10.4 °C to 12.7 °C. What is the specific heat capacity of the liquid?

Question 39

How much energy (in J) is lost when a sample of iron with a mass of 25.7 g cools from 75.0 °C to 22.0 °C?

Question 40

Classify each pictured sample as a pure substance or a mixture.

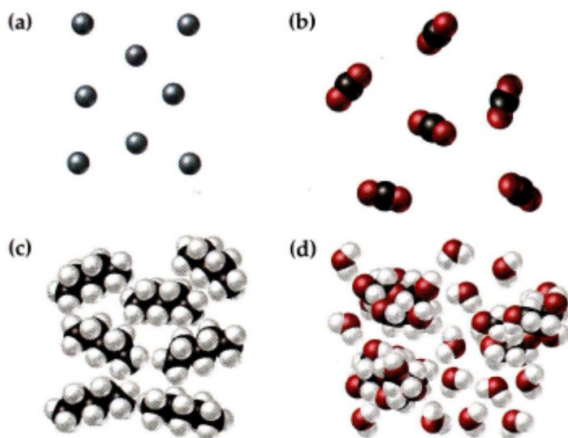


Figure description: Four molecular views. (a) Separate identical dark spheres. (b) Identical red-dark-red three-sphere molecules in different orientations. (c) Identical rings of dark spheres with white spheres attached. (d) Small red spheres each joined to two white spheres interspersed among larger molecules containing dark, red, and white spheres.

Question 41

Classify each pictured sample as a pure substance or a mixture. If pure, classify it as an element or a compound. If a mixture, classify it as homogeneous or heterogeneous.

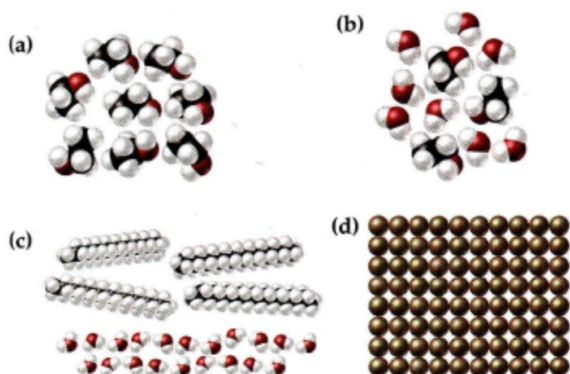


Figure description: Four molecular views. (a) Identical molecules containing dark, red, and white spheres. (b) Two kinds of small molecules interspersed throughout the view. (c) Long chains of dark and white spheres form an upper region, separated from small red-and-white molecules in a lower region. (d) A regular array of identical gold-colored spheres.

Question 42

The molecular drawing shows acetone molecules before and after a change. Was the change chemical or physical?

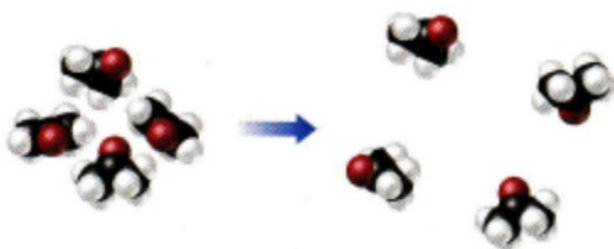


Figure description: Before: four acetone molecules are close together. After an arrow: four molecules with the same atom connections are farther apart.

Question 43

The molecular drawing shows methane and oxygen molecules before and after a change. Was the change chemical or physical?

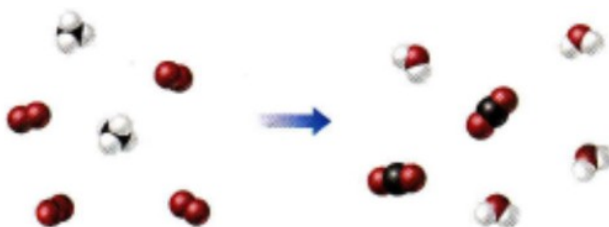


Figure description: Before: two methane molecules, each a carbon with four hydrogens, and four oxygen molecules, each a pair of oxygen atoms. After: two red-dark-red carbon dioxide molecules and four water molecules, each oxygen joined to two hydrogens.

Solutions

Find the solution with the same question number.

Question 1 Solution

A. A crystalline solid has a repeating arrangement that extends over long distances. An amorphous solid does not have this long-range order.

Question 2 Solution

E. None of statements A–D is false in the usual introductory description. Solids and liquids are approximately incompressible; gases are readily compressed.

Question 3 Solution

B. Salt is crystalline. Its particles form a repeating three-dimensional arrangement. Rubber, ordinary glass, and the plastics intended here are amorphous.

Question 4 Solution

B. Ice, understood here as pure frozen water, consists of H_2O . Seawater, air, and brass contain more than one substance and are mixtures.

Question 5 Solution

B. Raisin bran is a heterogeneous mixture. The raisins and bran remain distinct regions with different compositions.

Question 6 Solution

D. We can observe a physical property without changing the identity or chemical composition of the substance.

Question 7 Solution

A. Total mass is conserved. Add the product masses, then subtract the methane mass.

$$m(\text{oxygen}) = (36 + 44 - 16) \text{ g} = 64 \text{ g}$$

Question 8 Solution

A. Kinetic energy is energy associated with motion.

Question 9 Solution

C. Potential energy is associated with position or arrangement, such as a raised object or the arrangement of particles in a chemical system.

Question 10 Solution

A. A capital-C Calorie is 1000 small-c calories. Use the conversion factor supplied in this question.

$$95.0 \text{ Cal} \times \frac{1000 \text{ cal}}{1 \text{ Cal}} \times \frac{4.18 \text{ J}}{1 \text{ cal}} \times \frac{1 \text{ kJ}}{1000 \text{ J}} = 397 \text{ kJ}$$

Question 11 Solution

D. An endothermic process absorbs heat. Reversing that same change releases the heat, so the reverse process is exothermic.

Question 12 Solution

C. The sizes of a kelvin and a Celsius degree are equal, but their zero points differ. At ordinary atmospheric pressure, water boils at 100 °C, or about 373 K.

Question 13 Solution

D. Add 273.15 to the Celsius value.

$$T(\text{K}) = 27 + 273.15 = 300.15 \text{ K} \approx 300 \text{ K}$$

The given temperature is to the nearest degree, so report the result to the nearest kelvin.

Question 14 Solution

C. First find the temperature change. Use $c(\text{water}) = 4.18 \text{ J/(g } ^\circ\text{C)}$.

$$\Delta T = 50.0 - 25.0 = 25.0 \text{ } ^\circ\text{C}$$

$$q = mc\Delta T = (100.0 \text{ g})(4.18 \text{ J/(g } ^\circ\text{C)})(25.0 \text{ } ^\circ\text{C}) = 10450 \text{ J} = 10.5 \text{ kJ}$$

Question 15 Solution

D. Heat divided by mass and specific heat gives a temperature change, not the final temperature.

$$\Delta T = \frac{q}{mc} = \frac{40.5 \text{ J}}{(15.0 \text{ g})(0.128 \text{ J/(g } ^\circ\text{C)})} = 21.1 \text{ } ^\circ\text{C}$$

$$T(\text{final}) = 25.0 + 21.1 = 46.1 \text{ } ^\circ\text{C}$$

Question 16 Solution

B. For equal heat input and equal masses, the largest specific heat gives the smallest temperature increase.

$$\Delta T = \frac{q}{mc}$$

Water has the largest c , so it ends at the lowest temperature.

Question 17 Solution

C. The temperature change is $37 - 22 = 15\text{ }^{\circ}\text{C}$.

$$c = \frac{q}{m\Delta T} = \frac{49.5\text{ J}}{(7.3\text{ g})(15\text{ }^{\circ}\text{C})} = 0.45\text{ J/(g }^{\circ}\text{C)}$$

Question 18 Solution

Undo the operations in the reverse order: first multiply by 1.8, then add 32.

$$1.8\text{ T(C)} = \text{T(F)} - 32$$

$$\text{T(F)} = 1.8\text{ T(C)} + 32$$

The symbols T(C) and T(F) mean the numerical readings on the Celsius and Fahrenheit scales.

Question 19 Solution

- (a) Element: aluminum contains only Al atoms.
- (b) Element: sulfur contains only S atoms, even when they are joined into S₈ molecules.
- (c) Compound: methane contains C and H in CH₄.
- (d) Compound: acetone contains C, H, and O in C₃H₆O.

Question 20 Solution

- (a) Homogeneous for ordinary filtered black coffee.
- (b) Heterogeneous: the ice cream, chocolate, and other ingredients form distinct regions.
- (c) Homogeneous for clear, filtered apple juice. Juice with suspended pulp is heterogeneous.
- (d) Homogeneous: the liquid components of gasoline are uniformly mixed.

The classifications of coffee and juice depend on the stated or intended sample, not just the name of the drink.

Question 21 Solution

- (a) Pure substance, element: only He atoms.
- (b) Homogeneous mixture: several gases are uniformly mixed.
- (c) Heterogeneous mixture: distinct ingredients remain visible.
- (d) Heterogeneous mixture: cement, sand, and aggregate form distinct regions.

Question 22 Solution

- (a) Chemical: tarnishing produces new compounds at the surface.
- (b) Physical: observing shine does not change composition.
- (c) Physical: observing color does not change composition.
- (d) Chemical: burning changes propane into other substances.

Question 23 Solution

- (a) Chemical: hydrogen reacts, producing new substances.
- (b) Physical: propane remains propane while changing phase.
- (c) Chemical: combustion changes propane into other substances.
- (d) Chemical: the green coating consists of compounds formed from copper.

Question 24 Solution

The total product mass equals the total reactant mass. Oxygen contributes mass; it must be included.

$$m(\text{products}) = 42 \text{ kg} + 168 \text{ kg} = 210 \text{ kg}$$

Thus 210 kg of carbon dioxide and water are produced in total.

Question 25 Solution

- (a) Yes. $7.5 + 60.0 = 67.5 \text{ g}$, equal to the product mass.
- (b) No, as reported. Reactant mass is $60.5 + 243 = 303.5 \text{ g}$, whereas product mass is $206 + 88 = 294 \text{ g}$. The approximately 10-g discrepancy is much larger than the reported measurement precision. Some product or reactant information is missing or incorrect.

Question 26 Solution

Use conservation of mass, then solve for the unknown product mass.

$$m(\text{water}) = (9.7 + 34.7 - 29.3) \text{ g} = 15.1 \text{ g}$$

Question 27 Solution

Use $1 \text{ cal} = 4.184 \text{ J}$ and $1 \text{ Cal} = 1000 \text{ cal}$. A nutritional Calorie is not the same unit as a small-c calorie.

(a)

$$588 \text{ cal} \times \frac{4.184 \text{ J}}{1 \text{ cal}} = 2.46 \times 10^3 \text{ J}$$

(b)

$$17.4 \text{ J} \times \frac{1 \text{ Cal}}{4184 \text{ J}} = 4.16 \times 10^{-3} \text{ Cal}$$

(c)

$$134 \text{ kJ} \times \frac{1000 \text{ J}}{1 \text{ kJ}} \times \frac{1 \text{ Cal}}{4184 \text{ J}} = 32.0 \text{ Cal}$$

(d)

$$56.2 \text{ Cal} \times \frac{4184 \text{ J}}{1 \text{ Cal}} = 2.35 \times 10^5 \text{ J}$$

Question 28 Solution

A kilowatt-hour is a unit of energy: $1 \text{ kWh} = (1000 \text{ J/s})(3600 \text{ s}) = 3.6 \times 10^6 \text{ J}$, exactly.

(a)

$$25 \text{ kWh} \times \frac{3.6 \times 10^6 \text{ J}}{1 \text{ kWh}} = 9.0 \times 10^7 \text{ J}$$

(b)

$$249 \text{ cal} \times \frac{1 \text{ Cal}}{1000 \text{ cal}} = 0.249 \text{ Cal}$$

(c)

$$113 \text{ cal} \times \frac{4.184 \text{ J}}{1 \text{ cal}} \times \frac{1 \text{ kWh}}{3.6 \times 10^6 \text{ J}} = 1.31 \times 10^{-4} \text{ kWh}$$

(d)

$$44 \text{ kJ} \times \frac{1000 \text{ J}}{1 \text{ kJ}} \times \frac{1 \text{ cal}}{4.184 \text{ J}} = 1.1 \times 10^4 \text{ cal}$$

Question 29 Solution

First find intake minus expenditure, then convert that excess to kilojoules.

$$\text{Excess} = (2.2 - 2.0) \times 10^3 = 0.2 \times 10^3 \text{ Cal/day}$$

$$200 \text{ Cal/day} \times \frac{4.184 \text{ kJ}}{1 \text{ Cal}} = 836.8 \text{ kJ/day}$$

The subtraction limits the excess to about $8 \times 10^2 \text{ kJ/day}$. Retain the unrounded value for the next step.

$$\text{Time} = \frac{14.6 \times 10^3 \text{ kJ}}{836.8 \text{ kJ/day}} = 17.45 \text{ days}$$

This is roughly 17 days on the nominal data, or about 2×10^1 days at the precision implied by the rounded intake and expenditure. This uses the simplified energy-storage model specified in the question.

Question 30 Solution

The reaction is exothermic because heat leaves the reacting material and warms the surroundings.

In the energy diagram, place the reactants (iron and oxygen) on a higher energy level and the products (iron oxide) on a lower level. Draw a downward arrow from the reactant level to the product level and label it “energy released to the surroundings.”

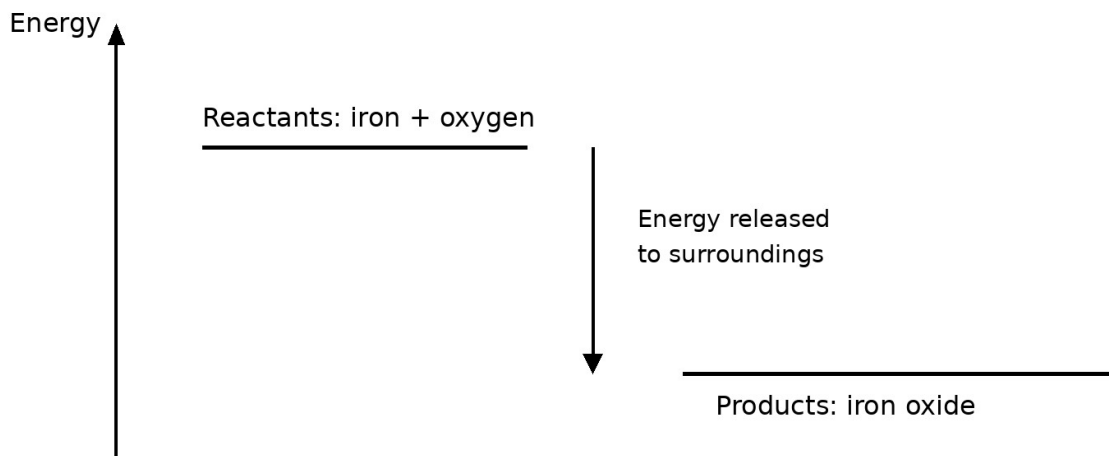


Figure description: Energy diagram: the reactant level is above the product level; a downward arrow indicates energy released to the surroundings.

Question 31 Solution

- (a) Exothermic: combustion releases heat.
- (b) Endothermic: evaporation absorbs energy from the skin and surroundings.
- (c) Exothermic: condensation releases energy as gas molecules enter the liquid phase.

Question 32 Solution

Use an offset when converting a temperature reading; do not treat it as a temperature difference.

(a)

$$T(C) = \frac{212 - 32}{1.8} = 100\text{ }^{\circ}\text{C}$$

(b)

$$T(C) = 77 - 273.15 = -196.15\text{ }^{\circ}\text{C}$$

$$T(F) = 1.8(-196.15) + 32 = -321.07\text{ }^{\circ}\text{F} \approx -321\text{ }^{\circ}\text{F}$$

(c)

$$T(K) = 25 + 273.15 = 298.15\text{ K} \approx 298\text{ K}$$

(d)

$$T(K) = \frac{98.6 - 32}{1.8} + 273.15 = 310.15\text{ K} \approx 310.2\text{ K}$$

Question 33 Solution

Apply the conversion to the supplied temperature.

$$T(\text{F}) = 1.8(-59.7) + 32 = -75.46\text{ }^{\circ}\text{F} \approx -75.5\text{ }^{\circ}\text{F}$$

Question 34 Solution

Use $c(\text{water}) = 4.184\text{ J}/(\text{g }^{\circ}\text{C})$.

$$\Delta T = 65 - 32 = 33\text{ }^{\circ}\text{C}$$

$$q = mc\Delta T = (65\text{ g})(4.184\text{ J}/(\text{g }^{\circ}\text{C}))(33\text{ }^{\circ}\text{C}) = 8974.68\text{ J}$$

The heat required is $9.0 \times 10^3\text{ J}$, or 9.0 kJ , to two significant figures.

Question 35 Solution

Use $c(\text{iron}) = 0.449\text{ J}/(\text{g }^{\circ}\text{C})$. Find the temperature increase, then add it to the initial temperature.

$$\Delta T = \frac{15\text{ J}}{(12\text{ g})(0.449\text{ J}/(\text{g }^{\circ}\text{C}))} = 2.8\text{ }^{\circ}\text{C}$$

$$T(\text{final}) = 28 + 2.8 = 30.8\text{ }^{\circ}\text{C} \approx 31\text{ }^{\circ}\text{C}$$

The initial temperature was specified to the nearest degree.

Question 36 Solution

Water has specific heat $1.000\text{ cal}/(\text{g }^{\circ}\text{C})$, equivalent to $4.184\text{ J}/(\text{g }^{\circ}\text{C})$.

$$\Delta T = \frac{248\text{ cal}}{(24\text{ g})(1.000\text{ cal}/(\text{g }^{\circ}\text{C}))} = 10.33\text{ }^{\circ}\text{C} \approx 1.0 \times 10^1\text{ }^{\circ}\text{C}$$

This is an increase of about $10\text{ }^{\circ}\text{C}$, to two significant figures.

Question 37 Solution

Divide the heat absorbed by the mass and the temperature change.

$$\Delta T = 39.9 - 31.1 = 8.8\text{ }^{\circ}\text{C}$$

$$c = q/(m\Delta T) = 58/[(28)(8.8)] = 0.2354\text{ J}/(\text{g }^{\circ}\text{C})$$

Report $c \approx 0.24\text{ J}/(\text{g }^{\circ}\text{C})$. The unrounded value agrees with silver, $0.235\text{ J}/(\text{g }^{\circ}\text{C})$.

Question 38 Solution

Divide the heat absorbed by the mass and the temperature change.

$$\Delta T = 12.7 - 10.4 = 2.3\text{ }^{\circ}\text{C}$$

$$c = q/(m\Delta T) = 56/[(11)(2.3)] = 2.2\text{ J}/(\text{g }^{\circ}\text{C})$$

Question 39 Solution

Use $c(\text{iron}) = 0.449\text{ J}/(\text{g }^{\circ}\text{C})$.

$$\Delta T = 22.0 - 75.0 = -53.0\text{ }^{\circ}\text{C}$$

$$q = (25.7 \text{ g})(0.449 \text{ J/(g } ^\circ\text{C)})(-53.0 \text{ } ^\circ\text{C}) = -612 \text{ J}$$

The iron loses 612 J. The negative sign on q indicates heat leaving the iron.

Question 40 Solution

- (a) Pure substance: all particles are the same individual atoms.
- (b) Pure substance: all particles are the same three-atom molecules; different orientations do not make different substances.
- (c) Pure substance: all molecules have the same ring structure.
- (d) Mixture: small water-like molecules and larger molecules are both present.

Question 41 Solution

- (a) Pure compound: the same molecules containing several elements repeat throughout.
- (b) Homogeneous mixture: two molecular species are interspersed throughout the sample.
- (c) Heterogeneous mixture: the long molecules and the small water-like molecules occupy separate regions.
- (d) Pure element: the array contains only one kind of atom.

Question 42 Solution

Physical. The acetone molecules retain the same structure. Only their spacing and arrangement change, as in evaporation.

Question 43 Solution

Chemical. The original molecules are rearranged into molecules with different atom connections: carbon dioxide and water.

