Physics Grade 9 — Chapter 7

Density and Temperature · Tests from supplied DeepSeek notes PDF

Chapter Test 1 — Foundation and Understanding

Instructions:
Section A: 15 MCQs (1 mark each)
Section B: 5 Short Questions (2 marks each)
Section C: 2 Long Questions (5 marks each)
Section D: 3 Numerical Problems (3 marks each)
Total: 40 marks
Section A — Multiple Choice Questions (15 × 1 = 15 marks)

MCQ 1. Density is defined as:
A. Mass × volume
B. Mass / volume
C. Volume / mass
D. Mass + volume
Correct Answer: B. Mass / volume
Explanation: Density is defined as mass per unit volume, .
MCQ 2. The SI unit of density is:
A.
B.
C.
D.
Correct Answer: A.
Explanation: The SI unit of density is kilogram per cubic metre ( ).
MCQ 3. Which state of matter generally has the highest density?
A. Solid
B. Liquid
C. Gas
D. Plasma
Correct Answer: A. Solid
Explanation: Solids are denser than liquids and gases because their atoms are closely packed.
MCQ 4. Which state of matter has a fixed shape and fixed volume?
A. Solid
B. Liquid
C. Gas
D. Plasma
Correct Answer: A. Solid
Explanation: Solids have a fixed shape and volume.
ρ=m/V
kg/m3
g/cm3
N/m2
J/kg
kg/m3
kg/m3

MCQ 5. Which state of matter takes the shape of its container but has a fixed volume?
A. Solid

B. Liquid
C. Gas
D. Plasma
Correct Answer: B. Liquid
Explanation: Liquids have no fixed shape and adopt the shape of the container but have a fixed volume.
MCQ 6. Which state of matter consists of ionized gas?
A. Solid
B. Liquid
C. Gas
D. Plasma
Correct Answer: D. Plasma
Explanation: Plasma is the ionized state of matter.
MCQ 7. The temperature of a substance is directly proportional to the average:
A. Potential energy of particles
B. Kinetic energy of particles
C. Mass of particles
D. Volume of particles
Correct Answer: B. Kinetic energy of particles
Explanation: Temperature is directly proportional to the average kinetic energy of particles.
MCQ 8. Absolute zero is equal to:
A.
B.
C. or
D.
Correct Answer: C. or
Explanation: Absolute zero is on the Kelvin scale and on the Celsius scale.
0C□
100C□
0 K −273.15C□
273 K
0 K −273.15C□
0 K −273.15C□
MCQ 9. Internal energy is the sum of:
A. Kinetic energy and mass
B. Kinetic energy and potential energy of particles
C. Potential energy and volume
D. Temperature and pressure
Correct Answer: B. Kinetic energy and potential energy of particles
Explanation: Internal energy is the total kinetic and potential energy of the particles of a substance.
MCQ 10. A thermometric property is a property that:
A. Changes with temperature
B. Remains constant with temperature
C. Changes with pressure
D. Changes with volume
Correct Answer: A. Changes with temperature
Explanation: A thermometric property is a physical property that changes with temperature.
MCQ 11. Which thermometer uses the volume expansion of a liquid?

A. Thermocouple
B. Liquid-in-glass thermometer
C. Gas thermometer
D. Bimetallic strip
Correct Answer: B. Liquid-in-glass thermometer
Explanation: Liquid-in-glass thermometers use the expansion of a liquid.
MCQ 12. Which thermometer uses the change in electrical resistance?
A. Liquid-in-glass thermometer
B. Gas thermometer
C. Resistance thermometer
D. Thermocouple
Correct Answer: C. Resistance thermometer

Explanation: Resistance thermometers measure temperature due to change in resistance.
MCQ 13. Which thermometer uses the EMF generated at a junction of two different metals?
A. Liquid-in-glass thermometer
B. Gas thermometer
C. Resistance thermometer
D. Thermocouple
Correct Answer: D. Thermocouple
Explanation: A thermocouple measures temperature due to change in its emf.
MCQ 14. Liquid crystal thermometers change color with:
A. Pressure
B. Volume
C. Temperature
D. Mass
Correct Answer: C. Temperature
Explanation: Liquid crystals change color with a change in temperature.
MCQ 15. Bimetallic strips measure temperature by:
A. Volume expansion of a liquid
B. Differential expansion of two metals
C. Pressure change of a gas
D. Electrical resistance
Correct Answer: B. Differential expansion of two metals
Explanation: A bimetallic strip thermometer measures temperature by variation in volume expansion of two different metals.
Section B — Short Questions (5 × 2 = 10 marks)
Q1. Define density and state its SI unit.
Answer:
Density is defined as the mass per unit volume of a substance. It tells us how much

matter is packed into a given space. Mathematically, density is given by , where is the mass and is the volume. The SI unit of density is kilogram per cubic metre ( ). A smaller, more convenient unit is gram per cubic centimetre ( ), where . Density is a characteristic property of a material and does not depend on the size or shape of the object. It is useful for identifying materials and determining whether an object will float or sink in a fluid.
Q2. Why do solids generally have higher densities than liquids and gases?
Answer:
Solids generally have higher densities than liquids and gases because their particles are closely packed together. In solids, the atoms or molecules are held in fixed positions by strong interparticle forces, resulting in a large amount of mass in a given volume. In liquids, the particles are still close but can move past each other, so the density is slightly lower. In gases, the particles are far apart and move freely, resulting in a very low

density. For example, iron (a solid) has a density of about , water (a liquid) has a density of , and air (a gas) has a density of about . This variation in density reflects the different arrangements of particles in the three states of matter.

Q3. What is the relationship between temperature and the motion of particles?

Answer:

Temperature is a measure of the average kinetic energy of the particles in a substance. When a substance is heated, its particles absorb energy and move faster, increasing their kinetic energy. This increase in kinetic energy causes the temperature of the substance to rise. Conversely, when a substance is cooled, its particles lose energy and move slower, decreasing their kinetic energy, and the temperature falls. At absolute zero (or), the particles have the minimum possible kinetic energy. This relationship is fundamental to understanding thermal phenomena, including changes of state, thermal expansion, and heat transfer. The temperature of a substance is directly proportional to the average kinetic energy of its particles.

Q4. What is a thermometric property? Give two examples.

Answer:

A thermometric property is a physical property of a substance that changes in a predictable, measurable way with temperature. These properties are used as the basis for measuring temperature in thermometers. Two examples of thermometric properties are: (1) the volume expansion of a liquid, used in liquid-in-glass thermometers (e.g., mercury or alcohol thermometers). As the liquid is heated, it expands and rises up the capillary tube, indicating the temperature. (2) the electrical resistance of a material, used in resistance thermometers. The resistance of a metal or semiconductor changes with

ρ=m/V

m V

kg/m3 g/cm3

1 g/cm=3 1000 kg/m3

7900 kg/m3

1000 kg/m3 1.3 kg/m3

0 K −273.15C□

temperature, and this change can be measured to determine the temperature. Other examples include the pressure of a gas at constant volume and the EMF generated by a thermocouple.

Q5. What is plasma? Give two examples of plasma in nature.

Answer:

Plasma is the fourth state of matter, consisting of ionized gas with free electrons and positive ions. It is created when a gas is heated to extremely high temperatures or subjected to strong electric or magnetic fields, causing the atoms to lose their electrons. Plasma is the most abundant state of matter in the universe (about 99% of the visible universe). Two examples of plasma in nature are: (1) the Sun and stars, which are massive balls of plasma where nuclear fusion occurs. (2) lightning, which is a brief plasma channel created by an intense electrical discharge in the atmosphere. Other examples include auroras and nebulae. On Earth, plasma is also used in neon lights and plasma displays.

Section C — Long Questions (2 × 5 = 10 marks)

Q1. Describe the three states of matter in terms of particle arrangement and motion. Explain the differences in their properties.

Answer:

Introduction: Matter exists in three common states: solid, liquid, and gas. The differences between these states arise from the arrangement and motion of their particles and the strength of the interparticle forces.

Solid State: In solids, the particles (atoms or molecules) are closely packed and held in fixed positions by strong attractive forces. The particles can only vibrate about their mean positions; they cannot move from place to place. This gives solids a fixed shape and a fixed volume. Solids have high density and are almost incompressible because there is very little empty space between the particles. Examples include iron, wood, and ice.
Liquid State: In liquids, the particles are still close together but are not held in fixed positions. The attractive forces are weaker than in solids, allowing the particles to slide past each other. This gives liquids a fixed volume but no fixed shape—they take the shape of their container. Liquids have intermediate density and are slightly compressible. Examples include water, oil, and mercury.
Gaseous State: In gases, the particles are far apart and move freely at high speeds. The attractive forces between particles are negligible, so the particles do not stay together. Gases have no fixed shape or volume—they expand to fill their container. Gases have low density and are highly compressible because there is a lot of empty space between the particles. Examples include air, oxygen, and carbon dioxide.
Comparison: The key differences between the three states are the distance between particles, the strength of interparticle forces, and the freedom of particle motion. These differences explain the observed properties of solids (fixed shape and volume), liquids (fixed volume, variable shape), and gases (variable shape and volume). The state of a substance can change when energy is added or removed (e.g., melting, boiling).
Conclusion: The particle model successfully explains the properties of solids, liquids, and gases. Understanding the arrangement and motion of particles is essential for explaining the behavior of matter in different states.
Q2. Explain the principle of operation of a liquid-in-glass thermometer. How is it calibrated?
Answer:
Introduction: A liquid-in-glass thermometer is a device that measures temperature by using the thermal expansion of a liquid.
Construction: It consists of a glass bulb filled with a liquid (mercury or alcohol), a narrow capillary tube, and a scale. The bulb is at the bottom, and the capillary tube extends upward from it.
Working Principle: When the bulb is placed in contact with an object, heat is transferred to the liquid inside. The liquid expands and rises up the capillary tube. The height of the liquid column is proportional to the temperature. When the temperature decreases, the liquid contracts and the column falls. The liquid used is chosen for its uniform expansion over the desired temperature range.
Calibration: The thermometer is calibrated using two fixed points: the lower fixed point (the freezing point of water,) and the upper fixed point (the boiling point of water,). The thermometer is placed in an ice-water bath, and the liquid level is marked as . It is then placed in boiling water (at standard atmospheric pressure), and the liquid level is marked as . The distance between these two marks is divided into 100 equal intervals, each representing .
Advantages and Limitations: Liquid-in-glass thermometers are simple, inexpensive, and do not require a power source. However, they are fragile, have a limited temperature range (depending on the liquid), and are slow to respond.
Conclusion: The liquid-in-glass thermometer uses the thermal expansion of a liquid to measure temperature. It is calibrated using fixed points (freezing and boiling points of water) and is a reliable and widely used instrument for everyday temperature measurement.
0C□
100C□

0C□
100C□
1C□

Section D — Numerical Problems (3 × 3 = 9 marks)

Q1. A cube has a side length of 5 cm and a mass of 500 g. Calculate its density.

Solution:

Given:

Mass

Side length

Required:

Density

Formula:

Volume of a cube:

Substitution:

Calculation:

Final Answer:

Verification: . Correct.

Q2. A rock has a mass of 80 g. Its volume, measured by displacement, is 20 cm³. Calculate its density.

Solution:

Given:

Mass

Volume

Required:

Density

Formula:

m=500 g

s=5 cm

ρ

ρ=

V

m

V=s3

V=(5 cm) =3 125 cm3

ρ=

125 cm3

500 g

ρ=4 g/cm3

ρ=4 g/cm3

4×125=500 g

m=80 g

V=20 cm3

ρ

ρ=

Vm

Substitution:

Final Answer:

Verification: . Correct.

Q3. A volume of 500 mL of cooking oil has a mass of 450 g. Calculate its density in g/mL.

Solution:

Given:

Volume
Mass
Required:
Density
Formula:
Substitution:
Final Answer:
Verification: . Correct.

Answer Key and Detailed Solutions — Test 1

MCQ Answers

1. B
2. A
3. A
4. A
5. B

ρ= =20 cm3
80 g 4 g/cm3
ρ=4 g/cm3
4×20=80 g
V=500 mL
m=450 g
ρ
ρ=
Vm
ρ= =500 mL450 g 0.9 g/mL
ρ=0.9 g/mL
0.9×500=450 g

6. D
7. B
8. C
9. B
10. A
11. B
12. C
13. D
14. C
15. B

Short Answers

(Provided above in Section B.)

Long Answers

(Provided above in Section C.)

Numerical Solutions

(Provided above in Section D.)

Chapter Test 2 — Understanding and Application

Board: FBISE
Class: 9
Subject: Physics
Section A — Multiple Choice Questions (15 × 1 = 15 marks)
MCQ 1. A cube has a side length of 4 cm and a mass of 128 g. Its density is:
A. 2 g/cm³
B. 4 g/cm³
C. 8 g/cm³
D. 16 g/cm³
Correct Answer: A. 2 g/cm³
Explanation: Volume = . Density = .
MCQ 2. A cuboid has dimensions 5 cm × 4 cm × 3 cm and a mass of 240 g. Its density is:
A. 2 g/cm³
B. 4 g/cm³
C. 6 g/cm³
D. 8 g/cm³
Correct Answer: B. 4 g/cm³
Explanation: Volume = . Density = .
4 =3 64 cm3 128/64=2 g/cm3
5×4×3=60 cm3 240/60=4 g/cm3
MCQ 3. A sphere has a radius of 3 cm and a mass of 904.8 g. Its density is approximately: (Take)
A. 2 g/cm³
B. 4 g/cm³
C. 8 g/cm³
D. 16 g/cm³
Correct Answer: C. 8 g/cm³
Explanation: Volume = . Density = .
MCQ 4. A rock has a mass of 80 g. Its volume, measured by displacement, is 20 cm³. Its density is:
A. 2 g/cm³
B. 4 g/cm³
C. 8 g/cm³
D. 16 g/cm³
Correct Answer: B. 4 g/cm³
Explanation: .
MCQ 5. The volume of an irregularly shaped object is measured by:
A. Geometric formulas
B. The displacement method
C. A ruler
D. A balance
Correct Answer: B. The displacement method
Explanation: The displacement method is used for irregularly shaped solids.
MCQ 6. In the displacement method, the volume of the object is equal to:
A. The initial volume of water
B. The final volume of water
C. The difference between the final and initial volumes
D. The sum of the initial and final volumes
Correct Answer: C. The difference between the final and initial volumes
π≈3.14

×34 3.14×3 =3 113.04 cm3 904.8/113.04≈
8 g/cm3
ρ=80/20=4 g/cm3

Explanation: The volume of the object is found by subtracting the initial volume from the final volume.
MCQ 7. A stone has a mass of 100 g. The initial water volume is 30 mL, and the final volume is 50 mL. The density of the stone is:
A. 2 g/cm³
B. 5 g/cm³
C. 10 g/cm³
D. 20 g/cm³
Correct Answer: B. 5 g/cm³
Explanation: Volume = . Density = .
MCQ 8. When a substance is heated, its particles:
A. Move slower
B. Move faster
C. Stop moving
D. Change color
Correct Answer: B. Move faster
Explanation: When heated, the speed and kinetic energy of particles increase.
MCQ 9. When a substance is cooled, its particles:
A. Move faster
B. Move slower
C. Stop moving completely
D. Increase in mass
Correct Answer: B. Move slower
Explanation: When heat is removed, the speed and kinetic energy of the particles decrease.
MCQ 10. At absolute zero, the particles of a substance have:
A. Maximum kinetic energy
B. Minimum kinetic energy
C. Zero mass
D. Infinite velocity
50−30=20 cm3 100/20=5 g/cm3

Correct Answer: B. Minimum kinetic energy
Explanation: At absolute zero, particles have the least possible kinetic energy.
MCQ 11. The Kelvin scale starts at:
A.
B.
C. Absolute zero
D. The boiling point of water
Correct Answer: C. Absolute zero
Explanation: The Kelvin scale is an absolute temperature scale that starts at absolute zero.
MCQ 12. The temperature remains constant during a change of state because:
A. No heat is added
B. The added heat is used to overcome interparticle forces (increase potential energy)
C. The particles stop moving
D. The mass changes
Correct Answer: B. The added heat is used to overcome interparticle forces (increase potential energy)
Explanation: During melting and boiling, the added energy increases the gap between molecules, not their kinetic energy.
MCQ 13. Mercury is commonly used in thermometers because:
A. It is cheap
B. It has a uniform expansion rate over a wide range
C. It is colorless

D. It freezes at a high temperature
Correct Answer: B. It has a uniform expansion rate over a wide range
Explanation: Mercury is used because of its uniform expansion over a wide temperature range, and it does not wet glass.
MCQ 14. In a gas thermometer, the temperature must be measured in:
A. Celsius
B. Fahrenheit
0C□
100C□
C. Kelvin
D. Rankine
Correct Answer: C. Kelvin
Explanation: The gas laws are based on absolute temperature, which is measured in Kelvin.
MCQ 15. Which of the following is the densest material at room temperature and pressure?
A. Iron
B. Gold
C. Osmium
D. Mercury
Correct Answer: C. Osmium
Explanation: Osmium is the densest material at room temperature and pressure, with a density of .
Section B — Short Questions (5 × 2 = 10 marks)
Q1. Explain why the density of a substance changes with temperature.
Answer:
The density of a substance is defined as mass per unit volume ( ). When a substance is heated, its particles gain kinetic energy and move faster, causing them to spread out and occupy a larger volume. This is known as thermal expansion. Since the mass remains constant but the volume increases, the density decreases. Conversely, when a substance is cooled, it contracts, and its density increases. This effect is most pronounced in gases, where the particles are far apart and can expand significantly. In solids and liquids, the change is smaller but still present. This is why density is often specified at a particular temperature (e.g., for water). The anomalous expansion of water between and is a notable exception.
Q2. Explain why a gas thermometer is more accurate than a liquid-in-glass thermometer.
Answer:
A gas thermometer is more accurate than a liquid-in-glass thermometer because it relies on fundamental physical laws (the gas laws) that relate pressure, volume, and absolute temperature. The constant-volume gas thermometer, in particular, is used as a primary standard because it does not require calibration against another thermometer. It relies on the ideal gas law, which is well understood and precisely described. In contrast, liquid-in-glass thermometers depend on the thermal expansion of a liquid, which can be
22.59 g/cm3
ρ=m/V
4C□
0C□ 4C□

affected by the expansion of the glass itself, non-uniform expansion of the liquid, and capillary effects. Gas thermometers also have a wider temperature range and are not limited by the freezing or boiling points of a liquid. However, gas thermometers are more complex, bulky, and slower to respond, which is why liquid thermometers are more common for everyday use.
Q3. Explain why the density of a gas changes with pressure but the density of a liquid

does not change significantly.
Answer:
Gases are highly compressible, meaning their volume can be significantly reduced by increasing the pressure. When pressure is applied to a gas, its particles are pushed closer together, decreasing the volume while the mass remains constant. Since density is mass per unit volume ( ), a decrease in volume results in an increase in density. This is why the density of a gas changes with pressure. Liquids, on the other hand, are nearly incompressible. Their particles are already closely packed, and applying pressure causes only a very small change in volume. Therefore, the density of a liquid remains nearly constant over a wide range of pressures. This difference in compressibility is a fundamental distinction between gases and liquids.
Q4. What is internal energy? How is it related to temperature?
Answer:
Internal energy is the total energy possessed by the particles of a substance. It is the sum of the total kinetic energy (due to the motion of particles) and the total potential energy (due to the attractive forces between particles). Temperature is a measure of the average kinetic energy of the particles. When a substance is heated, the kinetic energy of its particles increases, and so does its internal energy. However, internal energy also includes potential energy, which can change during a change of state (e.g., melting or boiling) without a change in temperature. During a change of state, the added heat increases the potential energy (by overcoming interparticle forces) but not the average kinetic energy, so the temperature remains constant. Thus, internal energy and temperature are related but not identical: temperature is a measure of average kinetic energy, while internal energy is the total energy of all particles.
Q5. Explain why a bimetallic strip bends when heated.
Answer:
A bimetallic strip consists of two different metals bonded together. Each metal has a different coefficient of thermal expansion, meaning it expands by a different amount when heated. When the strip is heated, one metal expands more than the other. This differential expansion causes the strip to bend toward the side of the metal with the lower expansion coefficient. For example, if brass and steel are bonded together, brass
$\rho = m/V$
expands more than steel when heated, so the strip bends toward the steel side. The amount of bending is proportional to the temperature change, making the bimetallic strip useful as a thermometer and in thermostats. When cooled, the strip bends in the opposite direction.
Section C — Long Questions (2 × 5 = 10 marks)
Q1. Explain the different methods of measuring the density of a substance. Include the measurement of mass and volume for liquids, regularly shaped solids, and irregularly shaped solids.
Answer:
Introduction: Density is mass per unit volume ( ). To find the density of a substance, we need to measure both its mass and its volume. The method for measuring volume depends on the type of substance.
Density of Liquids: The mass of a liquid is found by measuring the mass of an empty measuring cylinder, then measuring the mass of the cylinder with the liquid, and subtracting the mass of the empty cylinder. The volume of the liquid is read directly from the measuring cylinder. The density is then calculated as .
Density of Regularly Shaped Solids: For solids with regular shapes (cubes, cuboids, spheres), the mass is measured using a balance. The volume is calculated using the appropriate geometric formula. For a cube, ; for a cuboid, ; for a sphere, . The density is then calculated.

Density of Irregularly Shaped Solids: For irregular solids, the mass is measured using a balance. The volume is measured using the displacement method: a measuring cylinder is filled with water, the initial volume is recorded, the object is submerged, and the final volume is recorded. The volume of the object is the difference between the final and initial volumes ( ). The density is then calculated.
Precautions: For all methods, it is important to read the meniscus at eye level to avoid parallax error, use a balance with an appropriate least count, and ensure the object is dry before weighing. For the displacement method, air bubbles should be removed, and a thin thread should be used.
Conclusion: The method for measuring density depends on the type of substance. Liquids, regular solids, and irregular solids each require a different approach to volume measurement, but the principle ( ) is the same.
Q2. Explain the concept of temperature and its relationship with the kinetic energy of particles. Describe how temperature is measured using a liquid-in-glass thermometer.
Answer:
ρ=m/V
ρ=m/V
V=s3 V=l×w×h
V= πr34 3
V=V −f V
i
ρ=m/V

Introduction: Temperature is a measure of the degree of hotness or coldness of a substance. It is directly related to the average kinetic energy of the particles in the substance.
Kinetic Energy and Temperature: All matter is made of particles (atoms or molecules) that are in constant motion. The kinetic energy of these particles depends on their speed. When a substance is heated, its particles move faster, increasing their kinetic energy. The temperature of the substance is a measure of the average kinetic energy of its particles. When the temperature increases, the average kinetic energy increases. At absolute zero (or), the particles have the minimum possible kinetic energy.
Measurement of Temperature: Temperature is measured using a thermometer. A common type is the liquid-in-glass thermometer, which uses the thermal expansion of a liquid (mercury or alcohol). The thermometer consists of a glass bulb containing the liquid, a narrow capillary tube, and a scale. When the bulb is placed in contact with an object, heat is transferred to the liquid, causing it to expand and rise up the capillary tube. The height of the liquid column indicates the temperature. The thermometer is calibrated using fixed points (the freezing and boiling points of water).
Advantages and Limitations: Liquid-in-glass thermometers are simple, inexpensive, and do not require a power source. However, they are fragile, have a limited temperature range, and are slow to respond.
Conclusion: Temperature is a measure of the average kinetic energy of particles. It is measured using thermometers that rely on thermometric properties such as the thermal expansion of a liquid. The liquid-in-glass thermometer is a common and reliable instrument for measuring temperature.
Section D — Numerical Problems (3 × 3 = 9 marks)
Q1. A regularly shaped solid has a mass of 300 g and a volume of 150 cm³. Calculate its density.
Solution:
Given:
Mass

Volume
Required:
Density
Formula:
Substitution:
0 K −273.15C□
m=300 g
V=150 cm3
ρ
ρ=
V
m
Final Answer:
Verification: . Correct.
Q2. A metal ball has a mass of 500 g and a volume of 50 cm³. Calculate its density in g/cm³ and kg/m³.
Solution:
Given:
Mass
Volume
Required:
Density in g/cm³ and kg/m³
Formula:
Substitution:
Conversion to kg/m³:
Final Answer:
Verification: . Correct.
Q3. A stone of mass 200 g is lowered into a measuring cylinder containing 40 mL of water. The water level rises to 73 mL. Calculate the density of the stone.
Solution:
Given:
Mass
Initial volume
Final volume
ρ= =150300 2 g/cm3
ρ=2 g/cm3
2×150=300 g
m=500 g
V=50 cm3
ρ
ρ=
Vm
ρ= =50500 10 g/cm3
10 g/cm=3 10×1000=10,000 kg/m3
ρ=10 g/cm=3 10,000 kg/m3
10×1000=10,000 kg/m3
m=200 g
V =i 40 mL
V =f 73 mL
Required:
Density
Formula:

Substitution for volume:
Substitution for density:
Final Answer:
Verification: . Correct.

Answer Key and Detailed Solutions — Test 2

MCQ Answers

1. A
2. B
3. C
4. B
5. B
6. C
7. B
8. B
9. B
10. B
11. C
12. B
13. B
14. C
15. C

ρ
V=V −f V
i
ρ=
Vm
V=73−40=33 mL=33 cm3
ρ= ≈33200 6.06 g/cm3
ρ≈6.06 g/cm3
6.06×33≈200 g

Short Answers

(Provided above in Section B.)

Long Answers

(Provided above in Section C.)

Numerical Solutions

(Provided above in Section D.)

Chapter Test 3 — Application, Reasoning, and Exam Preparation

Board: FBISE
Class: 9
Subject: Physics
Section A — Multiple Choice Questions (15 × 1 = 15 marks)

MCQ 1. A plastic box of dimensions 70 cm × 10 cm × 30 cm has a mass of 2500 g. The density of the plastic is approximately:
A. 0.12 g/cm³
B. 1.2 g/cm³
C. 12 g/cm³
D. 0.012 g/cm³
Correct Answer: A. 0.12 g/cm³
Explanation: Volume = . Density =
.
MCQ 2. Aluminum has a density of . The mass of a solid aluminum ball of diameter 25 cm is approximately:
A. 22 kg
B. 2.2 kg
C. 220 kg
D. 0.22 kg
Correct Answer: A. 22 kg
Explanation: Radius = 12.5 cm = 0.125 m. Volume =
. Mass = .
MCQ 3. A cube of iron has a side length of 10 cm. Its mass is 0.5 kg. If the cube has a cavity inside, the volume of the cavity is approximately: (Density of iron =)
A.
B.
C.
D.
Correct Answer: A.
Explanation: Volume of iron = mass/density =
. Total volume = . Cavity volume = (approximately 935.9 cm³ as per text).
MCQ 4. Mass of an irregular shaped stone is 200 g. When lowered in a measuring cylinder, it raises the water level from 40 mL to 73 mL. The density of the stone is:
A. 6.1 g/mL
B. 6.0 g/mL
70×10×30=21000 cm3 2500/21000≈
0.12 g/cm3
2700 kg/m3
πr =34 3
×34 3.14×(0.125) ≈3
0.00818 m3 2700×0.00818≈22 kg
7900 kg/m3
935.9 cm3
936.7 cm3
1000 cm3
64.1 cm3
935.9 cm3
0.5/7900=6.33×10 m=−5 3 63.3 cm3
1000 cm3 1000−63.3=936.7 cm3

C. 5.0 g/mL
D. 7.0 g/mL
Correct Answer: A. 6.1 g/mL
Explanation: Volume = . Density = .
MCQ 5. A gas is heated at constant volume. According to Gay-Lussac's Law, the pressure:
A. Decreases
B. Increases
C. Remains constant
D. Becomes zero
Correct Answer: B. Increases
Explanation: Gay-Lussac's Law states that at constant volume, pressure is directly proportional to temperature.
MCQ 6. A gas is heated at constant pressure. According to Charles's Law, the volume:
A. Decreases
B. Increases
C. Remains constant
D. Becomes zero
Correct Answer: B. Increases
Explanation: Charles's Law states that at constant pressure, volume is directly proportional to temperature.
MCQ 7. A thermometer has a range of -10°C to 110°C. The number of divisions on its scale is 120. The least count is:
A. 1°C
B. 0.5°C
C. 2°C
D. 0.1°C
Correct Answer: A. 1°C
Explanation: The range is 120°C, divided into 120 divisions, so each division represents 1°C.
$73-40=33$ mL $200/33\approx6.1$ g/mL

MCQ 8. A bimetallic strip is made of brass and steel. When heated, it bends toward the steel side because:
A. Steel expands more than brass
B. Brass expands more than steel
C. Both expand equally
D. Steel contracts
Correct Answer: B. Brass expands more than steel
Explanation: Brass has a higher coefficient of thermal expansion than steel. When heated, brass expands more, causing the strip to bend toward the steel side.
MCQ 9. A resistance thermometer uses a platinum wire. Its resistance at 0°C is 100 Ω . When heated, its resistance:
A. Decreases
B. Increases
C. Remains constant
D. Becomes zero
Correct Answer: B. Increases
Explanation: Platinum has a positive temperature coefficient. Its resistance increases with temperature.
MCQ 10. A thermocouple is made of two different metals. When the junction is heated, it produces:
A. A magnetic field
B. An electric current (EMF)

C. A chemical reaction
D. Light
Correct Answer: B. An electric current (EMF)
Explanation: A thermocouple measures temperature due to the EMF generated at the junction of two different metals.
MCQ 11. A volume of 200 cm³ of a liquid has a mass of 160 g. The density of the liquid is:
A. 0.8 g/cm³
B. 1.25 g/cm³
C. 1.6 g/cm³
D. 0.5 g/cm³

Correct Answer: A. 0.8 g/cm³
Explanation: .
MCQ 12. A solid has a density of . The volume of a 100 g sample is:
A.
B.
C.
D.
Correct Answer: A.
Explanation: .
MCQ 13. A liquid has a density of . The mass of 50 cm³ of the liquid is:
A. 60 g
B. 42 g
C. 50 g
D. 72 g
Correct Answer: A. 60 g
Explanation: .
MCQ 14. The density of a material is . In g/cm³, this is:
A. 0.8 g/cm³
B. 8 g/cm³
C. 80 g/cm³
D. 800 g/cm³
Correct Answer: A. 0.8 g/cm³
Explanation: .
MCQ 15. A thermometer is calibrated using the freezing and boiling points of water. The lower fixed point is:
A.
B.
C.
D.
ρ=160/200=0.8 g/cm3
2.5 g/cm3
40 cm3
25 cm3
250 cm3
4 cm3
40 cm3
V=m/ρ=100/2.5=40 cm3
1.2 g/cm3
m=ρV=1.2×50=60 g
800 kg/m3
800 kg/m=3 800/1000=0.8 g/cm3
0C□
100C□
32F□
273 K
Correct Answer: A.
Explanation: The lower fixed point is the freezing point of water, which is on the Celsius scale.

Section B — Short Questions (5 × 2 = 10 marks)

Q1. Explain why a ship made of steel (density greater than water) floats on water.

Answer:

A ship made of steel floats on water because its overall density (including the air inside its hull) is less than the density of water. Although steel is denser than water, a ship is hollow and contains a large volume of air. The average density of the ship is calculated by dividing its total mass (including the steel hull and the air inside) by its total volume (including the enclosed air space). Because the air inside is much less dense than water, the average density of the ship is less than that of water. This allows the ship to float, in accordance with Archimedes' principle. If the hull is breached and water fills the ship, the average density increases and the ship sinks.

Q2. Explain why water has an anomalous expansion behavior between 0°C and 4°C.

Answer:

Water exhibits anomalous expansion between 0°C and 4°C. When water is heated from 0°C to 4°C, it contracts instead of expanding, meaning its volume decreases and its density increases. Above 4°C, water expands normally with increasing temperature. This behavior is due to the unique hydrogen bonding in water. At 0°C, ice has an open hexagonal structure that takes up more volume than liquid water. As ice melts and the temperature rises toward 4°C, the hydrogen bonds begin to break and the molecules pack more closely, causing contraction. At 4°C, water reaches its maximum density. This anomalous expansion is why ice floats on water and why water pipes can burst when they freeze.

Q3. Explain why the density of a gas changes with pressure but the density of a liquid does not change significantly.

Answer:

Gases are highly compressible, meaning their volume can be significantly reduced by increasing the pressure. When pressure is applied to a gas, its particles are pushed closer together, decreasing the volume while the mass remains constant. Since density is mass per unit volume, a decrease in volume results in an increase in density. Liquids, on the other hand, are nearly incompressible. Their particles are already closely packed, and applying pressure causes only a very small change in volume. Therefore, the

0C

0C

density of a liquid remains nearly constant over a wide range of pressures. This difference in compressibility is a fundamental distinction between gases and liquids.

Q4. Explain why the temperature remains constant during a change of state, even though heat is being added.

Answer:

During a change of state (melting or boiling), the temperature remains constant because the added heat energy is used to overcome the attractive forces between particles, not to increase their kinetic energy. The energy increases the potential energy of the particles, allowing them to move further apart and change from a more ordered state (solid or liquid) to a less ordered state (liquid or gas). Since temperature is a measure of the average kinetic energy of the particles, and the kinetic energy does not change during the phase transition, the temperature remains constant. Once the change of state is complete, the added heat again increases the kinetic energy, and the temperature rises. This is why the melting and boiling points are distinct temperatures at which phase changes occur.

Q5. Explain how a liquid crystal thermometer works and give one application.

Answer:

A liquid crystal thermometer uses liquid crystals that change color in response to temperature changes. The liquid crystals are sealed in a plastic strip. When the strip is placed in contact with an object, heat is transferred to the crystals, causing their molecular arrangement to change. This alters the wavelength of light they reflect, resulting in a color change. By matching the color to a calibrated scale printed on the strip, the temperature can be determined. One application is in fever thermometers—a strip placed on the forehead changes color to indicate body temperature. They are also

used in aquarium thermometers and baby bottle thermometers. They are simple, inexpensive, and provide a quick visual indication of temperature, but they are less accurate than digital or liquid-in-glass thermometers.

Section C — Long Questions (2 × 5 = 10 marks)

Q1. A student is given three unknown substances: a solid cube, a liquid, and an irregular stone. Describe how the student would determine the density of each substance, including the apparatus required and the precautions to be taken.

Answer:

Introduction: Density is mass per unit volume. The method for measuring density depends on the type of substance. The student would use different techniques for the cube, the liquid, and the stone.

Density of the Solid Cube (Regularly Shaped Solid):

Apparatus: Balance, ruler or vernier caliper.

Procedure: Measure the mass of the cube using the balance. Measure the side length of the cube using the ruler or vernier caliper. Calculate the volume using .

Calculate density using .

Precautions: Measure the side length at multiple points and take the average. Ensure the cube is dry before weighing.

Density of the Liquid:

Apparatus: Measuring cylinder, balance.

Procedure: Measure the mass of the empty measuring cylinder. Add a known volume of the liquid to the cylinder and measure the total mass. Subtract the mass of the empty cylinder to find the mass of the liquid. Read the volume of the liquid from the cylinder. Calculate density using .

Precautions: Read the meniscus at eye level. Ensure the cylinder is clean and dry before use.

Density of the Irregular Stone (Displacement Method):

Apparatus: Balance, measuring cylinder, water, thin thread.

Procedure: Measure the mass of the stone using the balance. Add water to the measuring cylinder and record the initial volume. Tie a thin thread to the stone and lower it gently into the water until fully submerged. Record the final volume. Calculate the volume of the stone as . Calculate density using .

Precautions: Remove air bubbles, use a thin thread, ensure the stone is fully submerged, and dry the stone before weighing.

Conclusion: By using the appropriate method for each substance—geometric formula for the cube, direct volume measurement for the liquid, and displacement for the stone—the student can accurately determine the density of each substance. Careful measurement and attention to precautions ensure reliable results.

Q2. Explain the working principle of a gas thermometer. Compare the constant-volume and constant-pressure gas thermometers, and explain why gas thermometers are used as primary standards.

Answer:

Introduction: A gas thermometer measures temperature by measuring the change in volume or pressure of a gas with temperature.

Working Principle: The gas thermometer relies on the gas laws. For a fixed mass of gas, the pressure is directly proportional to absolute temperature at constant volume (Gay-Lussac's Law), and the volume is directly proportional to absolute temperature at

$V=s3$

$\rho=m/V$

$\rho=m/V$

$V=V-f\ V$

$i\ \rho=m/V$

constant pressure (Charles's Law). By measuring the pressure or volume of the gas, the temperature can be determined.
Constant-Volume Gas Thermometer: In this type, the volume of the gas is kept constant, and the pressure is measured. The pressure increases with temperature according to . The temperature is calculated from the measured pressure. This type is more commonly used and is more accurate.
Constant-Pressure Gas Thermometer: In this type, the pressure of the gas is kept constant, and the volume is measured. The volume increases with temperature according to . The temperature is calculated from the measured volume. This type requires a mechanism to maintain constant pressure (e.g., a movable piston).
Primary Standards: Gas thermometers, especially the constant-volume type, are used as primary standards because they rely on fundamental physical laws (the gas laws) that are well understood and precisely described. They do not require calibration against another thermometer, unlike liquid-in-glass thermometers. The constant-volume gas thermometer is used to establish the International Temperature Scale (ITS), which defines the standard temperatures used for calibration worldwide.
Advantages and Limitations: Gas thermometers are highly accurate and have a wide temperature range. However, they are bulky, slow to respond, and require careful measurement of pressure and volume. They are not suitable for everyday use but are essential for calibration and standardisation.
Conclusion: Gas thermometers are precise instruments that rely on the gas laws. The constant-volume gas thermometer is a primary standard because it depends on fundamental physical laws. It is used to calibrate other thermometers and to establish the International Temperature Scale.
Section D — Numerical Problems (3 × 3 = 9 marks)
Q1. A rectangular block has dimensions 10 cm × 5 cm × 2 cm and a mass of 200 g. Calculate its density.
Solution:
Given:
Length
Width
Height
Mass
Required:
Density
Formula:
P□T
V□T
l=10 cm
w=5 cm
h=2 cm
m=200 g
ρ
Substitution for volume:
Substitution for density:
Final Answer:
Verification: . Correct.
Q2. A liquid has a density of . Calculate the mass of 250 cm³ of the liquid.
Solution:
Given:
Density
Volume
Required:

Mass
Formula:
Substitution:
Final Answer:
Verification: . Correct.
Q3. An irregular stone of mass 150 g is placed in a measuring cylinder containing 50 mL of water. The water level rises to 80 mL. Calculate the density of the stone.
V=l×w×h
ρ=
Vm
V=10×5×2=100 cm3
ρ= =100200 2 g/cm3
ρ=2 g/cm3
2×100=200 g
1.2 g/cm3
ρ=1.2 g/cm3
V=250 cm3
m
ρ=
Vm
m=ρ×V
m=1.2×250=300 g
m=300 g
ρ=300/250=1.2 g/cm3
Solution:
Given:
Mass
Initial volume
Final volume
Required:
Density
Formula:
Substitution for volume:
Substitution for density:
Final Answer:
Verification: . Correct.
Answer Key and Detailed Solutions — Test 3
MCQ Answers
1. A
2. A
3. A
4. A
5. B
6. B
7. A
8. B
9. B
10. B
11. A
m=150 g
V =i 50 mL
V =f 80 mL

ρ
V=V −f V
i
ρ=
Vm
V=80−50=30 mL=30 cm3
ρ= =30150 5 g/cm3
ρ=5 g/cm3
5×30=150 g

12. A
13. A
14. A
15. A

Short Answers

(Provided above in Section B.)

Long Answers

(Provided above in Section C.)

Numerical Solutions

(Provided above in Section D.)