Topic 1: Introduction to Earth's Changing Environment

Topic 1 Section 1

Overview: Earth Science's four disciplines

- Geology
- Oceanography
- Meteorology
- Astronomy

Observation: the perception of some aspect of the environment by one or more human senses (sight, hearing, touch, taste, or smell)

Instrument – a human made device that extends the senses beyond their normal limits

Inference: an interpretation of an observation

- A mental process that proposes causes, conclusions, or explanations of observations
- A prediction of a future event is an inference

Misconceptions: a mistaken belief or understanding

- Often result from incorrect inferences and become commonly believed
- Example: geocentric solar system – belief that the Sun and planets orbit the Earth

Classification: grouping similar observations and inferences to make the study of objects or events in the environment more meaningful or easier to understand

Measurement: a means of expressing an observation with greater accuracy or precision usually by means of adding a numerical value

In science, measured numbers have three parts:

Magnitude – size of the number	17.43
Unit – defines the type of quantity measured	17.43 grams
Precision – random error in a measurement	17.43(2) grams

The most common base dimensional quantities (or units) in Earth Science are:

- Length – a distance between two points
- Mass – the amount of matter (do not confuse with weight)
- Time – the sense of one thing happening after another or the duration of an event

Derived dimensional quantities require mathematical combination of base units:

Volume (cm^3 or h x w x l) and density (g/cm^3 or m/V) are examples of derived units

Percent Deviation – expresses the error or accuracy of a measurement

$$percent\ deviation = \frac{measured\ value - accepted\ value}{accepted\ value} \times 100\%$$

Example: A student measures the volume of a cube as 5.73 cm^3, but the known volume is 5.95 cm^3. Find the percent error.

$$\%_{dev} = \frac{meas - acc}{acc} \times 100\% = \frac{5.73\ cm^3 - 5.95\ cm^3}{5.95\ cm^3} \times 100\% = -3.7\%$$

Topic 1 Section 2

Density:

The concentration of matter in an object

The mass per unit volume of an object

Calculating density

$density = \frac{mass}{volume}$ or $D = \frac{m}{V}$

Density is a characteristic property:

It does not depend on size or shape

It does not change from object to object

It can be used to identify a substance

Example: find the density of a 20. cm^3 cube of graphite with a mass of 44 g.

V = 20. cm^3

m = 44 g

D = ?

$D = \frac{m}{V} = \frac{44\ g}{20\ cm^3} = 2.2\ g/cm^3$

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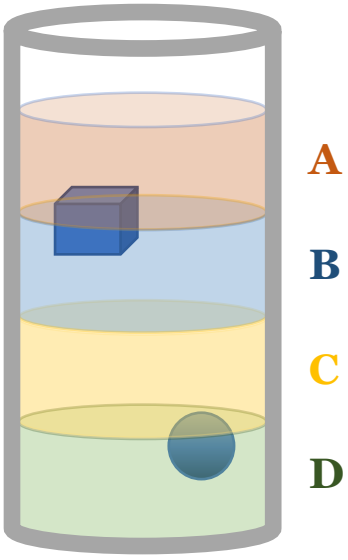
Note: because density is characteristic, the density of graphite is always the same.

Determining *relative density* (comparative density)

Usually accomplished by floatation in liquids or gases

The block is more dense than A but less dense than B

The ball is more dense than C but less dense than D



Physical changes that affect density

Changes in temperature, pressure, and phase can affect density

Temperature – increasing temperature increases the speed at molecules collide causes molecules to spread out; higher volume with the same mase decreases density

Pressure – increasing pressure forces molecules closer so the volume decreases and the density increases

Phase change

- changing from a gas to a liquid causes a large decrease in the volume so there is a large increase in the density
- changing from a liquid to a solid usually causes a significant decrease in the volume because chemical bonds become much stronger

water is a rare exception – when water freezes the molecules arrange in a way that leaves an open 'tunnel' so the volume increases significantly and the density changes from about 1 g/cm^3 to about 0.9 g/cm^3

This explains why ice floats in liquid water

Topic 1 Section 3

The changing environment: human observation shows that most environments are changing

Change occurs when the properties (or characteristics) of a part of the environment are altered

A change in an environment is called an *event*

Events may be:

nearly instantaneous such as lightning

very slow such as the change in elevation of mountains

Change can be described with respect to time and space (location)

The time and space in an event are frames of reference for studying the change

Rate of change

Field – any measurable aspect of an environment (temperature, elevation, rainfall)

$$rate\ of\ change = \frac{change\ in\ field\ value}{change\ in\ time}$$

Example: The temperature of a rock at 2:10 is 30°C. At 2:13, the temperature has increased to 40°C. Find the rate of change of temperature for the rock over this time period.

$$rate\ of\ change = \frac{change\ in\ field\ value}{change\ in\ time}$$

$$rate\ of\ change = \frac{40°C - 30°C}{2:13 - 2:10} = \frac{10°C}{3\ min} = 3.3°C/min$$

Cyclic change

An orderly change in the environment in which events constantly repeat

Examples: tides, daily temperatures, seasons, lunar phases, orbits of the planets

Prediction of change

Prediction – a type of inference about future conditions and behavior of the environment

Weather predictions can help reduce damages and loss of life

Energy, interfaces, and change

All change involves a flow of energy from one part of the environment (that loses energy) to another part of the environment (that gains energy)

Example: During an earthquake, internal energy stored in rocks is lost or released from the rocks and converted into sound, heat, and mechanical energy (the shaking of the Earth)

Energy is usually transferred across an *interface* (or boundary)

earthquake – from rocks at the focus to motion at the epicenter

ocean – from waves in the water to rocks and sand on the shore

space – from the upper atmosphere to outer space

heat – from land to the air

Environmental equilibrium

Equilibrium – a state in which opposing forces or influences are balanced

Dynamic equilibrium – a balanced state where the forces of change are constantly occurring

Example: water flows into the lake from a spring while water flows out of the lake from a creek but the water level in the lake is constant (Is the water the same each day?)

Topic 1 Section 4

Human interaction with the environment

Natural resources – materials and energy sources in the environment that humans use in their daily lives

- air
- water
- plants
- animals
- sunlight
- fossil fuels
- minerals

Conflict often arises over

- ownership, supply, and use of often limited natural resources
- trade-offs between alternate use of a resource and the conservation of land, water, or air

Shortages of resources can often be mitigated by

- substitution (LED lights instead of mercury vapor lamps)
- recycling (Al cans or reuse of glass bottles)

Pollution of the environment

Pollution occurs when the concentration of any substance or form of energy reaches a proportion that adversely affects people, their property, or other life forms

They key is the *concentration*

Salt is necessary for human life, but too much salt can cause injury or death

If streams become too warm, trout will die from lack of dissolved oxygen

We just learned that technology can often help if resources are scarce, but technology also produces and distributes harmful concentrations of substances and energy

Pollutants resulting from human technology include harmful car exhaust and CO_2, dissolved heavy metals in water leaching from mines, increased bacterial from poor waste management, and energy in the forms of heat, sound, and nuclear radiation

Pollutants can also result from natural causes such as pollen, volcanic ash and gases, radiation from uranium and radon in rocks and soils