

Who Powers It? Sorting the Water Cycle's Words by Energy and Gravity

Learning target: I can sort the processes of the water cycle by what drives them and by the change of state involved, and use the terms correctly in new situations.

Vocabulary in action

About 35 min

Individual

MS-ESS2-4 · practice

independent practice

visual modeling

discussion

Standards connections

MS-ESS2-4 (practice): MS-ESS2-4 is a California Grade 6 PE revisited here. Sorting each process by its driver (the sun's energy, cooling, or gravity) and its change of state is the vocabulary backbone of the model the PE asks students to develop.

Purpose: build · **Time:** about 35 minutes · **Format:** individual

Answers with reasoning

water cycle

The never-ending movement of water among the ocean, the air, the land, underground, and living things. The sun's energy and gravity keep it going. It has no starting point.

water vapor

Water in the gas state. It is invisible. Clouds, fog and 'steam' you can see are made of tiny liquid droplets or ice crystals, not vapor.

evaporation

The change from liquid water to water vapor at the surface of the liquid. It happens at any temperature, not only at boiling, because the fastest-moving molecules at the surface escape into the air.

transpiration

The movement of water from a plant's roots up to its leaves, where it evaporates inside the leaf and leaves through tiny pores (stomata) as water vapor.

melting

The change from solid ice to liquid water when ice gains enough energy.

condensation

The change from water vapor to liquid water. It happens when vapor cools enough, or when the air holds as much vapor as it can, and the slowed molecules gather on tiny specks of dust or salt. Water gives off energy to its surroundings as it condenses.

crystallization

The change into solid ice crystals. This lesson uses the word for both liquid-to-solid (scientists call that freezing) and gas-to-solid (scientists call that deposition, the way frost forms straight from vapor). Water gives off energy as it crystallizes.

precipitation

Water falling from clouds to the surface as rain, snow, sleet or hail, pulled down by gravity once the droplets or crystals grow heavy enough.

runoff

Liquid water flowing downhill over the land surface into streams, rivers, lakes and the ocean, moved by gravity.

infiltration

Liquid water soaking down from the surface into the open spaces in soil and rock, pulled by gravity.

groundwater

Water stored underground in the small spaces (pores) between grains of soil and rock. It is not an underground lake; it fills the gaps the way water fills a sponge.

aquifer

A body of rock or sediment whose pores are connected so that groundwater can flow through it, with enough water in it for a well or spring to draw on.

groundwater flow

The slow movement of groundwater through connected pores, downhill under gravity, toward springs, streams, lakes and in many places the ocean.

Part A: Sort nine processes by what drives them

Nine processes move water around the cycle: evaporation, transpiration, melting, condensation, crystallization, precipitation, runoff, infiltration and groundwater flow. Each one belongs in exactly one of three columns. Column 1: water **gains** energy, supplied by the sun. Column 2: water **gives off** energy as it cools. Column 3: **gravity** moves water that already is liquid or solid, with no change of state required.

1. Write each of the nine processes in the correct column. Columns will not be equal in length. Then, next to each process in Columns 1 and 2, write the change of state it involves (for example, *liquid to gas*).

Answer: Column 1 (gains energy, sun): evaporation (liquid to gas), transpiration (liquid to gas, inside the leaf), melting (solid to liquid). Column 2 (gives off energy, cooling): condensation (gas to liquid), crystallization (gas to solid, or liquid to solid). Column 3 (gravity, no change of state required): precipitation, runoff, infiltration, groundwater flow.

Why: Three, two and four processes. The textbook's Key Science Concept spread says each process is powered by the sun or by gravity; condensation and crystallization are actually driven by cooling (water losing energy), which is why this sheet uses three columns. Falling snow can melt and falling rain can freeze, but precipitation itself needs no change of state.

Also acceptable: Accept 'gas or liquid to solid' or just 'to solid' for crystallization. A student who puts melting under gravity because meltwater runs downhill has confused melting with the runoff that follows; mark it and discuss.

- All nine processes placed
- Changes of state written for the five Column 1 and 2 processes

2. Two of the nine processes are often described as 'powered by the sun' in diagrams, but the sun does not directly cause them: they happen when water vapor **loses** energy. Which two are they, and what actually has to happen to the vapor for them to occur?

Answer: Condensation and crystallization. The vapor has to lose energy: its molecules must slow down (usually because the air cools, for example as it rises) until they can stick together on specks of dust or salt. The sun drives the cycle as a whole, but these two steps happen when water gives energy away, not when it receives it.

Why: This is the accuracy correction to the textbook's 'sun or gravity' framing (see the chapter's accuracy notes). Condensation can also occur when air becomes saturated without much cooling, but cooling is the usual trigger.

Also acceptable: Accept 'the air has to get cold enough' or 'the air becomes full of vapor (saturated)'.

- Names condensation and crystallization
- States that the vapor must cool or lose energy (molecules slow)

Part B: Which term fits?

3. A hiker's wet socks dry on a rock in the shade at 15 °C. The water left the socks by _____.

Answer: evaporation

Why: The socks dried at 15 °C in the shade, far below boiling, which is the point: evaporation happens from a surface at any temperature.

Also acceptable: None; 'drying' is not a word-bank term.

4. On a freezing night, feathery ice forms on a car windshield that was dry at sunset. The lesson calls this _____; a scientist would add that because it went straight from gas to solid, it is also called deposition.

Answer: crystallization

Why: The windshield was dry, so the ice formed directly from vapor (deposition); the lesson's umbrella term is crystallization.

Also acceptable: Accept 'crystallization (deposition)'. Do not accept 'condensation', because no liquid formed.

5. After a storm, water seeps down through the soil of a baseball field instead of flowing across it. That process is _____, and once it is below the surface it is called _____.

Answer: infiltration; groundwater

Why: Soaking in from the surface is infiltration; water in the soil and rock pores below is groundwater.

Also acceptable: None.

6. A cornfield on a hot July day puts far more water into the air than the bare road next to it. The extra water leaves the plants by _____.

Answer: transpiration

Why: Plants carry water up from their roots; it evaporates inside the leaves and exits the stomata as vapor. A bare road has no such pathway.

Also acceptable: Accept 'transpiration (evaporation inside the leaves)'.

7. A spring bubbles out of a hillside even in a dry month. The water reaching the spring arrived by _____ through an _____.

Answer: groundwater flow; aquifer

Why: A spring that runs in a dry month is fed by groundwater moving slowly through connected pores, which is the definition of an aquifer.

Also acceptable: Accept 'groundwater' for the first blank if the second blank is 'aquifer'.

Part C: Apply the terms to new situations

8. A glass of ice water sits on a picnic table. Within minutes the outside of the glass is wet. Someone says the glass must be leaking. Use two terms from the word bank to explain what really happened and where the water came from.

Answer: The glass is not leaking. The air around the glass contains invisible water vapor. When that vapor touches the cold surface of the glass it cools, its molecules slow down, and it changes to liquid droplets: condensation. The water came from the air, not from inside the glass.

Why: Students must name water vapor as the source and condensation as the process. A student can add that the drops are fresh water even if the drink is juice, which is a nice test of the 'leak' idea.

Also acceptable: Accept 'the cold glass cooled the air next to it, so the vapor condensed.'

- Uses water vapor as the source
- Uses condensation as the process
- States the water came from the air

9. You breathe out on a cold morning and see a small white cloud. Is the white cloud water vapor? Use the terms *water vapor* and *condensation* to explain what you are seeing.

Answer: No. Water vapor is invisible. Your breath carries warm, moist air (lots of water vapor). When it meets the cold morning air it cools quickly, and the vapor condenses into tiny liquid droplets. The white cloud you see is those droplets, formed by condensation. A moment later they evaporate again and disappear.

Why: The key distinction of the lesson: vapor is invisible; what you see is liquid.

Also acceptable: Accept 'tiny water drops' for droplets.

- States the cloud is not vapor
- Explains that vapor condensed into droplets because it cooled

10. A city paves a large field to build a parking lot. Using *runoff*, *infiltration* and *groundwater*, predict two changes to how rainwater moves on that land after the paving.

Answer: After paving, rain cannot soak into the ground, so infiltration drops to almost zero. More water flows across the surface as runoff, so nearby streets and streams get more water faster and may flood. Less water reaches the groundwater below, so the groundwater is recharged less and wells or springs fed by it may get lower over time.

Why: Two changes, each using the terms correctly: less infiltration, more runoff, less groundwater recharge.

Also acceptable: Accept 'puddles and flooding' as a consequence of more runoff. A student who notes that the hot pavement increases evaporation from puddles is adding a correct idea.

- Predicts less infiltration
- Predicts more runoff
- Connects reduced infiltration to groundwater

11. A snowbank on a sunny, below-freezing day (-3°C) shrinks over a week without any puddle forming underneath. Which change of state must have happened, and why does this show that water can leave a solid without melting first? (The scientist's word for solid-to-gas is *sublimation*.)

Answer: The snow went directly from solid to gas (sublimation): the air stayed below freezing and no liquid ever appeared, so the snow did not melt away; it left as vapor. This shows that water molecules at the surface of ice can gain enough energy from sunlight to escape straight into the air as vapor, without passing through the liquid state.

Why: Sublimation is not in the lesson's nine processes, but the lesson's own logic (surface molecules gaining energy and escaping) explains it. Full credit needs solid-to-gas and the reason melting is ruled out.

Also acceptable: Accept 'the snow evaporated without melting' if the student says it went from solid to gas.

- Identifies solid to gas (sublimation)
- Rules out melting using the -3°C temperature or the missing puddle

Part D: Relationships between terms

12. *Evaporation* and *condensation* are often called opposites. In what way are they opposites, and what is the one thing they have in common when you think about energy?

Answer: They are opposites in direction: evaporation is liquid to gas, condensation is gas to liquid. What they share is that both involve an energy exchange with the surroundings, just in opposite directions: evaporation takes energy in (which is why it cools your skin), and condensation gives the same kind of energy back to the surrounding air.

Why: The relationship is reverse processes with reverse energy flow. A quantitative latent-heat answer is not expected (outside the assessment boundary).

Also acceptable: Accept 'both happen at the surface where water and air meet' as an additional similarity.

- Opposite direction of state change
- Both involve energy moving between water and surroundings

13. *Groundwater* and *aquifer* are not the same thing. Explain the difference in one or two sentences, the way you would to a sixth grader.

Answer: Groundwater is the water itself, sitting in the tiny spaces between grains of soil and rock underground. An aquifer is the rock or sediment that holds that water and whose spaces are connected so the water can move through it and be pumped from a well. Not all rock with a little water in it is an aquifer; it needs enough connected pores, and enough water, for a well or spring to draw on.

Why: Water versus the container-plus-water distinction; the sponge analogy is a good check.

Also acceptable: Accept 'groundwater is the water, an aquifer is where it is stored and can flow.'

- Groundwater = the water in pores
- Aquifer = the rock/sediment with connected pores that holds enough to supply a well

14. Odd one out: *precipitation, runoff, infiltration, condensation*. Which term does not belong with the other three, and why? (There is more than one defensible answer; explain yours.)

Answer: Most defensible: condensation, because the other three are moved by gravity with no change of state, while condensation is a change of state driven by cooling. Also defensible: precipitation, because it is the only one that happens in the atmosphere while the other three happen at or below the land surface; or infiltration, because it is the only one that takes water underground.

Why: The item rewards the reasoning, not a single answer. The driver-based answer (condensation) shows the deepest understanding of the lesson.

Also acceptable: Any of the three choices above with its stated reason earns full credit; 'runoff because it is on the surface' is weaker because precipitation also reaches the surface.

- A choice
- A reason based on a real property shared by the other three (driver, location, change of state)

Teacher notes

Definitions are original and correct where the textbook simplifies: transpiration has water evaporating inside the leaf and leaving as vapor (the book's page 235 says liquid water is released then evaporates; its page 240 caption agrees with this sheet); crystallization is kept as the lesson's and NGSS's umbrella term with freezing and deposition named; condensation and crystallization are driven by cooling, not directly by the sun (the Key Science Concept, printed 240-241 / PDF 276-277, says 'sun or gravity'). q1 is the heart of the sheet; have students compare tables in pairs before you reveal the key, and expect debate about melting (sun) versus runoff (gravity). Sublimation (q11, extension) is beyond the lesson but is a natural question in snow country; accept it as a tenth process in Column 1. Vocabulary pages in the lesson: printed 233-239 / PDF 269-275.

Scaffold offered to students: Two questions for every process

If you are stuck in Part A, ask two questions about the process. Question 1: Does the water change state? If it goes to a 'faster' state (solid to liquid, liquid to gas) it is gaining energy; if it goes to a 'slower' state (gas to liquid, gas or liquid to solid) it is giving off energy. Question 2: If the state does not change, what is moving the water? If it is going down or downhill, gravity is the answer.

Extension: A tenth process

The lesson lists nine processes, but water can also go straight from solid ice to water vapor without melting; scientists call this sublimation, and it is why snow can shrink on a cold, dry, sunny day. Write a word-bank-style definition of sublimation, decide which column of Part A it belongs in and explain why, and name one place on Earth where you would expect a lot of it (think cold, dry, and sunny).