



Unit 11 • The Earth and Universe: minerals and the Earth's history

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Key words

1. mineral
2. mineralogy
3. ore
4. ferrous
5. gems
6. energy minerals
7. Precambrian
8. reptiles

K • 4

Each carries 0.5 mark.

2 Label the diagram

- | | |
|-----------------|-------------|
| 1. Metallic | 5. Precious |
| 2. Ferrous | 6. Gems |
| 3. Non-ferrous | 7. Energy |
| 4. Non-metallic | 8. Non-gems |

K • 4

Each carries 0.5 mark.

3 Multiple choice

- i. c. mineralogy

K • 1

Mineralogy is the branch of geology that studies minerals. Geology studies the whole Earth, paleontology studies fossils, and archaeology studies the remains of past human life.

- ii. b. The Earth formed from a hot lump pulled out of the Sun by the strong gravity of a giant star passing quickly by.

K • 1

In the tidal hypothesis, a passing star's gravity pulled a cigar-shaped "tide" of hot matter out of the Sun, which cooled into planets. Formation from nebular dust is the nebular hypothesis.

- iii. b. non-ferrous mineral

U • 1

Aluminium is a metal, so bauxite is a **metallic** mineral; it has little or no iron, so it is **non-ferrous**. It isn't precious: aluminium is the most common metal in the Earth's crust, and bauxite is mined by the millions of tonnes.

- iv. c. All the planets go round the Sun in nearly one plane and in the same direction.

U • 1

If everything formed from **one flat, spinning disc**, everything should still go round in that disc's plane and direction, and it does. The size order of the planets is what the tidal hypothesis tried to explain; the Sun having no partner is the criticism of the binary hypothesis.

- v. c. coal burnt in a brick kiln

A • 1

In the kiln, coal is **burnt** for its heat, so it is used as a source of energy. The limestone, sand and slate become part of the product itself: they are raw materials.

4 Very short answers

- a. MARKING SCHEME

K • 1

✓ About 4.6 billion years ago.

- b. MARKING SCHEME

K • 1

✓ The Cenozoic era.



- c. MARKING SCHEME K · 1
✓ Any one: Udayapur, Makwanpur, Chobhar.

5 Short answers

- a. MARKING SCHEME U · 2
✓ Any one difference, e.g. a metal can be extracted from a metallic mineral, not from a non-metallic one.
✓ Any second difference, e.g. metallic minerals are usually hard, shiny, dense and good conductors; non-metallic minerals are light and poor conductors; or examples: hematite, galena; mica, gypsum.
- b. MARKING SCHEME U · 2
✓ A mineral is homogeneous and has a definite chemical composition.
✓ Every sample is the same element or compound in the same proportions wherever it is found (quartz is always SiO_2), so it is a pure substance.
- c. MARKING SCHEME U · 2
✓ In the Mesozoic, forests of conifers and other gymnosperms (pines, cycas, ginkgo, juniper) replaced the fern forests.
✓ They covered almost all the moist land and were the main plants of the era.
- d. MARKING SCHEME K · 2
✓ i. Mammoths: the Cenozoic era.
✓ ii. Lungfish: the Paleozoic era.

6 Long answers

- a. ANSWER U · 4
The hypotheses are the nebular hypothesis (Kant and Laplace), Buffon's planetesimal hypothesis, the binary hypothesis (Chamberlin and Moulton) and the tidal hypothesis (Jeans and Jeffreys). The nebular hypothesis: where the Solar System is now there was a huge, slowly turning cloud of gas and dust, a nebula. Gravity pulled its particles to the center, which grew, spun faster and became hot enough for nuclear fusion: the Sun. The rest of the cloud flattened into a spinning disc, in which particles gathered into lumps that grew into the planets, their moons and the asteroids and comets. So all the planets go round the Sun in nearly one plane and in the same direction.
- MARKING SCHEME
- ✓ The four hypotheses named: nebular, planetesimal, binary and tidal.
✓ One explained, e.g. nebular: a huge, slowly turning cloud of gas and dust (nebula) was pulled together by gravity.
✓ Its center spun faster and became hot enough to shine: the Sun.
✓ The rest flattened into a disc, where lumps grew into the planets and moons (so the planets go round in one plane, in one direction).



b. ANSWER

A • 4

- i. The Mesozoic era: they appeared in the Triassic period and died out at the end of the Cretaceous, 66 million years ago.
- ii. An asteroid about 10 km wide hit the Earth; fires and dust blocked sunlight for months, plants died and food chains collapsed. Huge volcanic eruptions in India made it worse.
- iii. An open question. For example: giant plant-eaters would clear forests and compete with elephants, rhinos and cattle for food, and big meat-eaters would hunt large mammals; mammals and humans might never have spread, and food chains would be very different.

MARKING SCHEME

- ✓ i. The Mesozoic era.
- ✓ ii. An asteroid about 10 km wide hit the Earth (66 million years ago).
- ✓ ii. Dust and soot blocked sunlight, so plants died and food chains collapsed (or: huge volcanic eruptions in India).
- ✓ iii. A reasoned opinion, e.g. they would compete with and hunt today's large mammals, so food chains would be different and humans might not have spread.

7 Numerical problem**ANSWER**

A • 2

- i. $540 \div 4,600 \times 100 \approx 11.7\%$, about 12%. (ii) $540 - 250 = 290$ million years (nearly 300 million years).

MARKING SCHEME

- ✓ i. $540 \div 4,600 \times 100 \approx 12\%$.
- ✓ ii. $540 - 250 = 290$ million years.

8 Think**ANSWER**

HA • 2

The **Archeozoic era**, the earliest part of the **Cryptozoic eon**, was unsuitable for life for most of its length. The Earth was extremely hot and kept melting under the impacts of huge rocks; there was no stable crust and at first no oceans; the air was made of volcanic gases such as carbon dioxide, ammonia, methane and sulphur dioxide, with no oxygen to breathe and no ozone layer to block the Sun's ultraviolet rays. For example, a fish or a fern could not have survived even a minute: no water to live in, and nothing to breathe. Only near the end of this era, once the Earth had cooled and the oceans had formed, did the first simple cells appear.

MARKING SCHEME

- ✓ The Archeozoic era (the earliest part of the Cryptozoic eon).
- ✓ The Earth was very hot and kept melting under impacts, with no stable crust and at first no oceans, and its air of volcanic gases had no oxygen; e.g. a fish could not have lived: no water and nothing to breathe.

9 Activity: A mineral chart (Activity 11.1)

(not marked)

WHAT STUDENTS SHOULD FIND

For example: quartz, colorless or white, six-sided prisms or grains in sand, glassy, solid; mica, colorless to dark brown, thin flat sheets, pearly, solid; salt (halite), white, cubes, glassy, solid; graphite, dark gray, flaky with no clear shape, metallic and greasy, solid. Every mineral is a solid; its color, shape and shine help to tell one from another.

See it at Science Playground

Exhibits and plants at the center, Bhaktapur, that go with this unit. Book a class visit at science-playground.com/booking.

- **Stone & Mineral Collection** (exhibit): Compare the specimens' color, shine and weight: each is made of different minerals.



- **Geodes (exhibit):** Look inside the geode at crystals that grew from mineral-laden water, layer on layer.
- **The Hourglass (exhibit):** The sand runs at a steady rate; atoms in rocks change at a steady rate too, keeping time.
- **The Spiral of Life on Earth (exhibit):** Follow the spiral's 4.6 billion years: plants, animals and humans arrive very late.
- **Ginkgo (garden):** Ginkgo is a living fossil: its fan-shaped leaf has hardly changed since the dinosaurs.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	15	12	7	2	36





Unit 11 • The Earth and Universe: the universe

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Key words

1. universe
2. light-year
3. Big Bang
4. asteroid belt
5. coma
6. meteor
7. galaxy
8. constellation

K • 4

Each carries 0.5 mark.

2 Label the diagram

- | | | |
|---|--|-------|
| 1. coma cloud of gas and dust | 5. ion tail charged gas: straight, bluish,
exactly away from the Sun | K • 3 |
| 2. Sun | | |
| 3. nucleus ice, dust and rock, a few km
across | 6. dust tail dust: broad, whitish, curved,
shines by reflected sunlight | |
| 4. direction of motion | | |

Each carries 0.5 mark.

3 Multiple choice

- i. **b. Lemaître** K • 1
Georges Lemaître proposed in 1927 that the universe is expanding, and that it began from a “primeval atom”.
- ii. **a. Shoemaker–Levy 9** K • 1
Comet Shoemaker–Levy 9 broke into pieces and crashed into Jupiter in July 1994. Halley and Tempel–Tuttle still go round the Sun.
- iii. **d. stars, nebular dust and gas clouds** U • 1
A galaxy is a huge collection of **stars**, with clouds of **gas and dust** (nebulae). Rock, metal and dust make an asteroid; ice, gas and dust make a comet.
- iv. **b. always away from the Sun** U • 1
The Sun’s light and the solar wind push the gas and dust **away from the Sun**. So when a comet is moving away from the Sun, its tail actually goes in **front** of it. This surprises most people.
- v. **b. It lies almost exactly above the Earth’s North Pole, so it stays nearly still in the north while other stars turn around it.** A • 1
The Earth spins on an axis that points almost straight at the Pole Star, so it seems to stay still over the north all night and all year, while every other star circles around it. It is not especially bright: about the 48th brightest star in the sky.

4 Very short answers

- a. **MARKING SCHEME** K • 1
✓ 88.
- b. **MARKING SCHEME** K • 1
✓ The Milky Way.



- c. MARKING SCHEME U · 1
✓ The sunlit sky is much brighter than the meteors, so they can't be seen in the day.

5 Short answers

- a. MARKING SCHEME U · 2
✓ Any one difference, e.g. a meteor is the streak of light of a meteoroid burning up in the air; a meteorite is the piece that reaches the ground.
✓ Any second difference, e.g. a meteor is seen high in the sky (80–100 km) for a second or two and is harmless; a meteorite is a solid rock on the ground, and a large one can make a crater.
- b. MARKING SCHEME U · 2
✓ Any one difference, e.g. asteroids are made of rock and metal; comets of ice, dust and rock.
✓ Any second difference, e.g. asteroids have no tail and are mostly between Mars and Jupiter; comets grow a coma and tails near the Sun and come from the Kuiper belt and the Oort cloud.
- c. MARKING SCHEME U · 2
✓ Their orbits come close to, or cross, the Earth's orbit, so one could hit the Earth.
✓ An asteroid hits at many kilometers per second, so even a small one carries enormous energy (a 10-km asteroid wiped out the dinosaurs).
- d. MARKING SCHEME U · 2
✓ Meteoroids enter the air at 11 to 72 km per second, and the air in front of them is squeezed and heated so much that they glow and burn up about 80–100 km up.
✓ Most are tiny, like grains of sand, so they burn up completely; only a few large ones leave a meteorite.

6 Long answers

- a. ANSWER U · 4
In 1927 Georges Lemaître worked out that the universe is expanding, and in 1929 Edwin Hubble showed that distant galaxies are moving away from us, the farther ones faster. Going backwards, about 13.8 billion years ago all the matter and energy of the universe was packed into one tiny, extremely hot, dense state (Lemaître's primeval atom), which began to expand very fast: the Big Bang. As it expanded it cooled: subatomic particles formed, then atoms (mostly hydrogen and helium) and molecules; gravity then gathered the gas into stars, galaxies and nebulae, and much later planets. The universe is still expanding. Evidence: the galaxies moving apart, the faint afterglow of the Big Bang found in 1965, and the amounts of hydrogen and helium.
- MARKING SCHEME
- ✓ About 13.8 billion years ago all the matter and energy was in one tiny, very hot, dense state (the primeval atom), which began to expand very fast: the Big Bang.
✓ As it expanded it cooled: subatomic particles, then atoms (hydrogen and helium) and molecules formed.
✓ Gravity gathered the gas into stars, galaxies and nebulae, and later planets; the universe is still expanding.
✓ Any one piece of evidence or history, e.g. Hubble (1929) found galaxies moving apart; Lemaître (1927); the afterglow found in 1965.



b. ANSWER

K · 4

Asteroids are small rocky or metallic bodies that go round the Sun (minor planets). Most lie in the asteroid belt between Mars and Jupiter; some (Trojans) share a planet's orbit, and some (near-Earth asteroids) cross the Earth's orbit. Most are irregular in shape, because their gravity is too weak to make them round. They range from a few meters to about 1,000 km (Ceres, about 940 km, is the largest), and are made of rock, minerals, metals such as iron and nickel, and clay. They have no tail.

MARKING SCHEME

- ✓ Any one characteristic, e.g. small rocky or metallic bodies that go round the Sun (minor planets).
- ✓ Any second, e.g. most are in the asteroid belt between Mars and Jupiter (some are Trojans or near-Earth asteroids).
- ✓ Any third, e.g. most have an irregular shape, as their gravity is too weak to make them round.
- ✓ Any fourth, e.g. sizes from a few meters to about 1,000 km (Ceres); made of rock, metals and clay; no tail.

7 Numerical problem**ANSWER**

A · 2

Distance = $4.2 \times 9.46 \times 10^{12}$ km $\approx 3.97 \times 10^{13}$ km, about 40 trillion km. Its light takes about 4.2 years to reach us (a light-year is the distance light travels in one year).

MARKING SCHEME

- ✓ $4.2 \times 9.46 \times 10^{12} \approx 3.97 \times 10^{13}$ km (about 40 trillion km).
- ✓ About 4.2 years.

8 Think**ANSWER**

HA · 2

The Moon has no air, so even small meteoroids are not burnt up: they hit its surface and blast out craters. It also has no wind, rain, rivers or living things to wear the craters away, so craters billions of years old are still there. On the Earth, the air burns up the small ones, and weather, water and the moving crust have erased most old craters.

MARKING SCHEME

- ✓ The Moon has no air to burn up meteoroids, so even small ones hit it and make craters.
- ✓ The Moon has no wind, rain or water to wear craters away, while on the Earth the air burns up small meteoroids and weather and the moving crust erase old craters.

9 Activity: Your own sky watch (Activity 11.5)

(not marked)

WHAT STUDENTS SHOULD FIND

The Milky Way is a pale, glowing band across the sky, seen only far from city lights. The Saptarishi is a ladle of seven stars in the north (high on spring and early-summer evenings); its two pointer stars lead to the Pole Star, which stays almost still over the north. Orion, with three stars in a row as its belt, is in the south-east on winter evenings; Scorpius is low in the south in summer. A planet looks like a bright star that doesn't twinkle much. A meteor is a quick streak of light lasting a second or two.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	15	15	3	2	35

