Grade 9 Optional Science Model Paper 3

ANSWER KEY

Full marks 75 · 2.25 hours

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

A practice paper by Science Playground, made to CDC's Specification Grid 2076, Science (Optional); not an official CDC or exam board paper.

Section A

16 × 1 = 16

a. The ribosome.

Marking scheme

- Ribosome.

b. By budding.

Marking scheme

- Budding.

c. Gregor Mendel, who worked out the laws of inheritance from his experiments on peas.

Marking scheme

- Gregor Mendel.

d. A wetland is land that is under shallow water or waterlogged for all or much of the year, such as a lake, a marsh or a floodplain.

Marking scheme

- Land under shallow water or waterlogged for all or much of the year.

e. Phagocytosis is the process in which phagocytes (white blood cells such as neutrophils and macrophages) take in germs, enclose them and digest them.

Marking scheme

- White blood cells (phagocytes) taking in germs and digesting them.

f. 18 ($2n^2$ with $n = 3$).

Marking scheme

- 18.

g. Absolute zero is −273 °C (0 K), the temperature at which the volume of a gas would become zero if it went on shrinking as Charles's law says.

Marking scheme

- −273 °C, or 0 K.

h. It is the fraction of the dissolved molecules that split into ions.

Marking scheme

- The fraction of dissolved molecules that split into ions.

i. A functional group is an atom or a group of atoms in an organic compound that decides its chemical properties, such as −OH in alcohols.

Marking scheme

- An atom or group of atoms that decides the chemical properties of an organic compound.

j. A catalyst is a substance that changes the rate of a chemical reaction without itself being permanently changed, such as manganese dioxide in the decomposition of hydrogen peroxide.

Marking scheme

- A substance that changes the rate of a reaction without being used up (permanently changed).

k. Impulse is the product of a force and the time for which it acts; it equals the change in momentum ($Ft = mv - mu$).

Marking scheme

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- Force × time it acts (= change in momentum).

l. A beta particle is a fast electron shot out of a nucleus when one of its neutrons turns into a proton.

Marking scheme

- A fast electron emitted from the nucleus (a neutron turning into a proton).

m. For a given pair of media and a given color of light, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant: $\sin i / \sin r = \text{constant}$.

Marking scheme

- sin i ÷ sin r is constant for a given pair of media (and color of light).

n. Capacitance is the ratio of the charge on either plate of a capacitor to the potential difference between its plates, $C = Q/V$.

Marking scheme

- Charge on a plate ÷ potential difference between the plates (C = Q/V).

o. The magnetic meridian is the vertical plane in which a freely hanging compass needle settles.

Marking scheme

- The vertical plane in which a freely suspended magnetic needle comes to rest.

p. A lahar is a mudflow of volcanic ash mixed with water that rushes down the slopes of a volcano.

Marking scheme

- A mudflow of volcanic ash and water.

Section B

13 × 2 = 26

2. Any two: **[2]**

Cell wall	Cell membrane
Fully permeable: lets water and dissolved substances pass freely.	Selectively permeable: lets some substances through and stops others.
Made of cellulose in plants (chitin in fungi, peptidoglycan in bacteria).	Made of a phospholipid bilayer with proteins.
Found in plants, fungi and most bacteria, not in animals.	Found in every cell.
Thick and rigid; gives shape and strength.	Thin (about 8 nm) and flexible.

Marking scheme

- One correct difference.
- A second correct difference.

3. Any two: **[2]**

Binary fission (*E. coli*)	Budding (yeast)
In a prokaryote.	In a eukaryote.
DNA is copied and pulled apart; no spindle.	The nucleus divides by mitosis.
Gives two equal cells.	Gives a big mother cell and a small bud.
The parent is gone (it becomes the two cells).	The parent lives on, with a bud scar.
Doubles in about 20 minutes.	Doubles in about 1½–2 hours.

Marking scheme

- One correct difference.
- A second correct difference.

4. Any two: **[2]**

Hereditary variation	Environmental variation
Caused by differences in the genes.	Caused by how one lives (food, work, sunlight).

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Hereditary variation	Environmental variation
Passed on to the offspring.	Not passed on.
Example: blood group, free or attached earlobe.	Example: a wrestler's strong arms, a tan, a scar.

Marking scheme

- One correct difference.
- A second correct difference.

5. Any two: **[2]**

Vaccine	Antibiotic
Prevents disease; given to healthy people.	Cures disease; given to sick people.
Works by making the body's own active immunity.	Acts on the bacteria directly.
Against bacteria and viruses.	Against bacteria only.
Protection lasts for years.	Works only while it is taken.

Marking scheme

- One correct difference.
- A second correct difference.

6. Chlorine has two isotopes, chlorine-35 and chlorine-37, with different masses. Its relative atomic mass is the average of their masses weighted by how common each is (about 75.8% chlorine-35 and 24.2% chlorine-37), which comes to about 35.5; no single chlorine atom has this mass. **[2]**

Marking scheme

- Chlorine has two isotopes, Cl-35 and Cl-37.
- The atomic mass is their average weighted by abundance, so it isn't whole.

7. Any two: **[2]**

Ideal gas	Real gas
Obeys the gas laws exactly at all temperatures and pressures.	Obeys them closely only at low pressure and high temperature.
Its molecules have no volume of their own.	Its molecules have a small volume of their own.
Its molecules don't attract each other.	Its molecules attract each other weakly.
Can never be turned into a liquid.	Turns into a liquid when cooled and squeezed.
Only a model; doesn't exist.	Every gas.

Marking scheme

- One correct difference.
- A second correct difference.

8. Any two: **[2]**

Organic compounds	Inorganic compounds
Contain carbon, nearly always with hydrogen.	Made of any elements; most contain no carbon.
Covalent.	Many are ionic.
Low melting and boiling points.	Ionic ones have high melting and boiling points.
Most don't dissolve in water but dissolve in kerosene or alcohol.	Many dissolve in water.
Most burn.	Most don't burn.
React slowly.	Ionic ones often react at once.

Marking scheme

- One correct difference.

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- A second correct difference.

9. Sulphur combines with mercury even in the cold: Hg + S → HgS. The mercury is turned into solid mercury sulphide, which does not give off poisonous mercury vapor and is easy to sweep up. **[2]**

Marking scheme

- Hg + S → HgS.
- Mercury is changed to solid mercury sulphide, so no poisonous vapor and it can be swept up.

10. Any two: **[2]**

Moment of a force	Couple
One force turning a body about a pivot.	Two equal, opposite, parallel forces.
Its value depends on the point about which it is taken.	Its moment is the same about every point.
Can also tend to move the body (the pivot holds it).	Only turns the body.
Example: opening a door, a wrench on a nut.	Example: a steering wheel, turning a tap or key.

Marking scheme

- One correct difference.
- A second correct difference.

11. Alpha particles are positive and beta particles negative, so the field pushes them opposite ways. An alpha particle is about 7,300 times as heavy as a beta particle, so it is much harder to turn and bends far less, though its charge is twice as big. **[2]**

Marking scheme

- Opposite charges (alpha positive, beta negative), so they bend opposite ways.
- Alpha is much heavier (about 7,300 times), so it bends much less.

12. The core of the fiber is optically denser than the cladding around it. Light inside meets the boundary at an angle greater than the critical angle, so it is totally internally reflected, again and again along the fiber. Total internal reflection sends back all the light, so very little is lost, unlike reflection from a mirror. **[2]**

Marking scheme

- The core is denser than the cladding; light meets the boundary at more than the critical angle.
- So it is totally internally reflected again and again, with almost no light lost.

13. The tangent to a line of force at any point gives the direction of the magnetic field there. If two lines crossed, there would be two tangents at that point, meaning the field pointed two ways at once, which is impossible. **[2]**

Marking scheme

- The tangent to a line gives the field's direction at that point.
- At a crossing the field would have two directions, which is impossible.

14. Any two: **[2]**

P waves	S waves
Faster (about 6 km/s); arrive first.	Slower (about 3.5 km/s); arrive next.
Push and pull the rock along their path.	Shake the rock from side to side.
Travel through solids, liquids and gases.	Travel through solids only.

Marking scheme

- One correct difference.
- A second correct difference.

Section C

7 × 3 = 21

15. For a cube of side a: $\dfrac{\text{surface area}}{\text{volume}} = \dfrac{6a^2}{a^3} = \dfrac{6}{a}$ **[3]**

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- 1 µm cube: 6 ÷ 1 = 6 µm² for each µm³
- 10 µm cube: 6 ÷ 10 = 0.6 µm² for each µm³

The bigger cell has only a tenth as much surface for each bit of its inside, so food and oxygen entering through the membrane can't keep up with what its middle needs. Cells stay small so that every part is close to the surface.

Marking scheme

- 1 µm cube: ratio 6 (per µm).
- 10 µm cube: ratio 0.6 (per µm).
- A large cell has too little surface for its volume to supply its middle, so cells stay small.

16. Number of lytic cycles: $n = \dfrac{60\ \text{min}}{30\ \text{min}} = 2$ **[3]**

$N = N_0 \times b^n = 1 \times 150^2 = 22{,}500$ phages

Marking scheme

- Number of cycles n = 60 ÷ 30 = 2.
- Uses N = $N_0 \times b^n$ = 1 × 150².
- N = 22,500 phages.

17. Let boron-10 be x%; then boron-11 is $(100 - x)$%. **[3]**

$\dfrac{10x + 11(100 - x)}{100} = 10.8 \Rightarrow 1100 - x = 1080 \Rightarrow x = 20$

Boron-10: 20%; boron-11: 80%.

Marking scheme

- Sets up 10x + 11(100 − x) = 10.8 × 100.
- Boron-10 = 20%.
- Boron-11 = 80%.

18. i. Cathode: $Cu^{2+} + 2e^- \rightarrow Cu$ (copper is deposited). Anode: $4OH^- \rightarrow 2H_2O + O_2 + 4e^-$ (oxygen is given off; sulphate ions are not discharged). **[3]**

ii. The Cu^{2+} ions, which make the solution blue, are deposited on the cathode, and the carbon anode does not dissolve to replace them, so their number falls. The solution slowly turns into dilute sulphuric acid.

Marking scheme

- Cathode: $Cu^{2+} + 2e^- \rightarrow Cu$.
- Anode: $4OH^- \rightarrow 2H_2O + O_2 + 4e^-$.
- Cu^{2+} ions are removed and not replaced by the carbon anode, so the blue fades.

19. $\sin c = \dfrac{1}{\mu} = \dfrac{1}{1.6} = 0.625 \Rightarrow c \approx 38.7^\circ$ **[3]**

The ray meets the surface at 45°, which is greater than the critical angle (38.7°) and is going from the denser plastic into rarer air, so it does not come out: it is totally internally reflected.

Marking scheme

- sin c = 1/µ = 1/1.6 = 0.625.
- c ≈ 38.7°.
- 45° > c, so the ray is totally internally reflected (doesn't come out).

20. $Q = CV = 220 \times 10^{-6} \times 9 = 1.98 \times 10^{-3}$ C **[3]**

Number of electrons $= \dfrac{Q}{e} = \dfrac{1.98 \times 10^{-3}}{1.6 \times 10^{-19}} \approx 1.24 \times 10^{16}$

Marking scheme

- C = 220 × 10^{-6} F, Q = CV.
- Q = 1.98 × 10^{-3} C.
- Electrons = Q ÷ e ≈ 1.24 × 10^{16}.

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21. Difference in magnitude: $d = 7.8 - 5.7 = 2.1$ **[3]**

Wave height ratio $= 10^{d} = 10^{2.1} \approx 126$ times

Energy ratio $= 10^{1.5d} = 10^{3.15} \approx 1{,}400$ times

Marking scheme

- Difference d = 2.1.
- Waves 10^2.1 ≈ 126 times larger.
- Energy 10^3.15 ≈ 1,400 times more.

Section D

3 × 4 = 12

22. i. Many vultures feed together on each carcass, and each vulture feeds on a great many carcasses in its life. So one treated carcass poisons many birds, and sooner or later almost every vulture eats from one. **[4]**

ii. No. Bacteria and fungi decompose a carcass slowly, but vultures clear it within hours. Without vultures:

- carcasses lie rotting for longer, spreading germs into water and the air around them, so more disease;
- stray dogs eat the carcasses instead and multiply, bringing more dog bites and more rabies.

A fall in one population changes the populations linked to it, people among them.

iii. The number of stray dogs will fall. Vultures will eat the carcasses first, so the dogs lose that extra food, and a population falls when its food runs short.

Marking scheme

- Many vultures feed on one carcass, and each feeds on many carcasses, so one treated carcass poisons many (or almost every vulture meets one).
- Disagrees: carcasses rot longer without vultures, spreading germs and disease.
- Stray dogs eat the carcasses and multiply: more bites and rabies.
- Stray dogs fall, because vultures take the carcasses and the dogs' food runs short.

23. i. P is ethanol, CH_3CH_2OH, an alcohol: it has an –OH group, and every alcohol reacts with sodium to give hydrogen. Q is methoxymethane, CH_3OCH_3, an ether: its oxygen sits between two carbons, with no –OH, so it doesn't react. **[4]**

ii. P (ethanol) boils at 78 °C and Q (methoxymethane) at −25 °C. Ethanol's molecules attract one another through their –OH groups, so more heat is needed to separate them; the ether has no –OH, so its molecules hold together weakly.

iii. The same atoms are joined in different ways, so P and Q have different functional groups (–OH and –O–), and the functional group decides how a compound behaves. Compounds with the same molecular formula but different structures are called isomers.

Marking scheme

- P: ethanol, CH_3CH_2OH; its –OH reacts with sodium to give hydrogen.
- Q: methoxymethane, CH_3OCH_3; no –OH, so no reaction.
- P boils at 78 °C, Q at −25 °C: ethanol's –OH groups hold its molecules together, the ether has none.
- Atoms joined differently give different functional groups and so different properties: isomers.

24. Take east as positive. **[4]**

i. $4{,}000 \times 10 + 1{,}000 \times (-15) = 40{,}000 - 15{,}000 = 25{,}000$ kg m/s east.

ii. By the conservation of momentum, $(4{,}000 + 1{,}000)\,v = 25{,}000 \Rightarrow v = 5$ m/s east.

iii. From −15 m/s to +5 m/s: a change of 20 m/s (from west to east). The bus changes only by 5 m/s.

iv. Both change in the same short time, but the car's velocity changes four times as much, so its people have a much greater acceleration and much greater forces act on them.

Marking scheme

- Total momentum = 25,000 kg m/s east.

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- Common velocity = 5 m/s east.
- Car's change = 20 m/s.
- The car's much larger change of velocity in the same time means larger acceleration (force) on its people.

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