Grade 10 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 NEB paper.

Section A

16 × 1 = 16

a. G_0 is the state of a cell that has left the cell cycle from G_1 and stopped dividing, as most nerve cells do for life.

Marking scheme

- A cell that has left the cycle from G_1 and stopped dividing.

b. A semipermeable membrane lets water pass through it but not larger dissolved substances.

Marking scheme

- A membrane that lets water through but not larger solutes.

c. A carrier has one recessive allele for the disease and shows no sign of it, but can pass it on to children.

Marking scheme

- One recessive allele, no sign of the disease, can pass it on.

d. A biogeochemical cycle is the circulation of an element between living things and the air, water, soil and rocks.

Marking scheme

- Circulation of an element between living things and the non-living environment.

e. An isograft is an organ or tissue transplanted from an identical twin; it is not rejected because the genes are the same.

Marking scheme

- A graft from an identical twin.

f. Ionization potential is the minimum energy needed to remove the most loosely held electron from one isolated gaseous atom: $X(g) \rightarrow X^+(g) + e^-$.

Marking scheme

- Minimum energy to remove the most loosely held electron from an isolated gaseous atom.

g. Vapor density is the mass of a volume of a gas divided by the mass of the same volume of hydrogen at the same temperature and pressure.

Marking scheme

- Mass of a volume of gas ÷ mass of the same volume of hydrogen (same T and P).

h. A photochemical reaction is a reaction started or driven by light, such as photosynthesis or $2AgCl \rightarrow 2Ag + Cl_2$.

Marking scheme

- A reaction started or driven by light.

i. An elimination reaction is one in which atoms leave two neighboring carbon atoms and a multiple bond forms between them.

Marking scheme

- Atoms leave two neighboring carbons and a multiple bond forms.

j. Roasting is heating an ore strongly in plenty of air, usually a sulphide ore ($2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$).

Marking scheme

- Heating an ore strongly in plenty of air.

k. Escape velocity is the smallest speed with which a body must be thrown from a planet's surface to escape its gravitational field and never return (ignoring air).

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Marking scheme

- Smallest speed from the surface to escape the planet's field and never return.

l. Latent heat is the heat taken in or given out during a change of state, at constant temperature.

Marking scheme

- Heat absorbed or released during a change of state without a change in temperature.

m. Magnification is the height of the image divided by the height of the object, $m = h_i/h_o$ (= v/u).

Marking scheme

- Image height ÷ object height.

n. A semiconductor is a substance whose conductivity lies between that of a conductor and an insulator, such as silicon or germanium.

Marking scheme

- A substance conducting between a conductor and an insulator.

o. The Curie temperature is the temperature above which a ferromagnetic material becomes paramagnetic (770 °C for iron).

Marking scheme

- Temperature above which a ferromagnetic material becomes paramagnetic.

p. A planetarium is a domed theater whose projector shows the sky and its motions on the dome.

Marking scheme

- A domed theater that projects the sky and its motions.

Section B

13 × 2 = 26

2. Distilled water is hypotonic to both cells, so water enters them by osmosis. A red blood cell has only a thin cell membrane, which can't hold the swelling, so it bursts (hemolysis). A plant cell has a strong cell wall, which presses back on the swelling protoplast, so the cell only becomes turgid. **[2]**

Marking scheme

- Water enters both by osmosis (distilled water is hypotonic).
- The plant cell's rigid wall stops it swelling too far (turgid); the red cell has no wall, so it bursts.

3. A trophozoite has no protective wall: outside the body it dies within minutes to hours, and the acid of the stomach kills it if swallowed. The mature cyst has a thick wall, lives for weeks in water or food, and passes through the stomach unharmed to the intestine, where it releases amoebae. **[2]**

Marking scheme

- Trophozoites die outside the body and in stomach acid (no wall).
- The cyst's thick wall lets it survive outside and pass the stomach.

4. The gene for color blindness is on the X chromosome. A father gives his X chromosome to his daughters and his Y chromosome to his sons, so his son gets his mother's X, not the father's affected one. (All his daughters will be carriers.) **[2]**

Marking scheme

- The gene is X-linked.
- A father passes his Y, not his X, to a son.

5. Energy comes in as sunlight, passes from producers to consumers as food, and at each level most of it is lost as heat in respiration; heat can't be used again by producers, so new sunlight is always needed. Matter such as carbon and nitrogen is returned to the soil, water and air by decomposers and respiration, and producers take it up again, so it cycles. **[2]**

Marking scheme

- Energy ends as heat, which living things can't use again, so it flows one way.
- Matter is returned by decomposers and respiration and taken up again, so it cycles.

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6. NH_4^+ forms when nitrogen of NH_3 gives its lone pair to an H^+ ion. Once formed, a coordinate bond is a shared pair of electrons between two atoms exactly like any covalent bond; the arrow only records where the pair came from. So the four N–H bonds are alike, pointing to the corners of a tetrahedron at 109.5°. **[2]**

Marking scheme

- N's lone pair is given to H^+ to form the fourth bond.
- Once formed it is a shared pair like any covalent bond, so all four are identical.

7. NH_4Cl is a salt of a strong acid (HCl) and a weak base (NH_4OH). It hydrolyses: $NH_4Cl + H_2O \rightleftharpoons NH_4OH +$ HCl, and HCl is fully ionized while NH_4OH is not, so there are extra H^+ ions and the solution is acidic. NaCl comes from a strong acid and a strong base, so it does not hydrolyse and stays neutral. **[2]**

Marking scheme

- NH_4Cl (strong acid + weak base) hydrolyses, giving extra H^+: acidic.
- NaCl (strong acid + strong base) doesn't hydrolyse: neutral.

8. Aqueous KOH (substitution): $C_2H_5Br + KOH \rightarrow C_2H_5OH + KBr$. **[2]**

Alcoholic KOH (elimination): $CH_3CH_2Br + KOH \rightarrow CH_2{=}CH_2 + KBr + H_2O$.

Marking scheme

- $C_2H_5Br + KOH\ (aq) \rightarrow C_2H_5OH + KBr$.
- $CH_3CH_2Br + KOH\ (alc) \rightarrow CH_2{=}CH_2 + KBr + H_2O$.

9. Shake each gas with bromine water. Ethene removes the orange-brown color, because bromine adds across its C=C double bond ($CH_2{=}CH_2 + Br_2 \rightarrow CH_2BrCH_2Br$). Ethane has only single bonds, so it doesn't react and the color stays. **[2]**

Marking scheme

- Ethene decolorizes bromine water (addition at C=C).
- Ethane, saturated, leaves the color.

10. Gravity is still pulling the astronauts (it provides the centripetal force of their orbit), but the Station and everyone in it are falling round the Earth together at the same rate. Nothing pushes up on the astronauts from the floor, so they feel weightless and float. **[2]**

Marking scheme

- Gravity still acts (it keeps them in orbit).
- Station and astronauts fall together, so there is no push from the floor: they float.

11. The Moon's escape velocity is low, only about 2.38 km/s, because its mass is small. Some gas molecules move faster than this, so over time they escaped and the Moon lost any air it had. **[2]**

Marking scheme

- The Moon's escape velocity is low (about 2.4 km/s), as its mass is small.
- Gas molecules moving faster than that escape, so the air leaked away.

12. In normal adjustment the magnification is $M = f_o/f_e$, so a long f_o and a short f_e give a large magnification. (Equal lenses would give M = 1.) The objective is also made large to gather more light and show finer detail. **[2]**

Marking scheme

- $M = f_o \div f_e$.
- So long f_o and short f_e give large magnification.

13. An object just beyond F of a convex lens gives a real, inverted and magnified image far away, which can be caught on a screen. Because the image is inverted, the slide is put in upside down so the picture on the screen is the right way up. **[2]**

Marking scheme

- Just beyond F the lens gives a real, magnified image far away on the screen.
- The image is inverted, so the slide is put in upside down.

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

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Relative dating	Absolute dating
Gives the order of events.	Gives ages in years.
No numbers.	Numbers of years.
Uses rules such as superposition and cross-cutting, and fossils.	Uses radioactive clocks (carbon-14, uranium–lead, potassium–argon), tree rings.

Marking scheme

- One correct difference.
- A second correct difference.

Section C

7 × 3 = 21

15. **[3]**

i. Dividing cells = 70 + 15 + 10 + 25 = 120; mitotic index $= \frac{120}{1{,}000} \times 100\% = 12\%$.

ii. $\frac{15}{1{,}000} \times 20\ \text{h} = 0.3$ h = 18 minutes.

iii. Prophase: the most dividing cells (70) are in it, and the time in a stage is in proportion to the cells found in it.

Marking scheme

- Mitotic index = 12%.
- Metaphase = 0.3 h (18 minutes).
- Prophase, as it has the most cells.

16. Each session: 4 + 1.5 + 1.5 = 7 hours **[3]**

A year: $7 \times 3 \times 52 = 1{,}092$ hours

$\frac{1{,}092}{24} \approx 45.5$ days

A transplant frees the patient from dialysis for good: over a month and a half of every year is given back, so the patient can work, study and live a better life (and over the years it costs less than lifelong dialysis).

Marking scheme

- 7 × 3 × 52 = 1,092 hours a year.
- About 45.5 days.
- A transplant frees the patient from dialysis: a better life (or lower cost over the years).

17. By Avogadro's law, the numbers in the equation give the ratio of the volumes of gases. **[3]**

Oxygen $= 5 \times 2 = 10$ L; carbon dioxide $= 3 \times 2 = 6$ L.

Air $= \frac{10}{0.21} \approx 48$ L

Marking scheme

- Oxygen = 10 L.
- CO_2 = 6 L.
- Air ≈ 48 L.

18. **[3]**

$n(\text{Cu}) = \frac{9.525}{63.5} = 0.15$ mol

3 mol Cu give 2 mol NO, so $n(\text{NO}) = \frac{2}{3} \times 0.15 = 0.10$ mol

Volume $= 0.10 \times 22.4 = 2.24$ L at STP

Marking scheme

- Moles of Cu = 0.15.
- Moles of NO = 0.10 (3 : 2).
- Volume = 2.24 L.

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19. Heat to melt all the ice $= 0.05 \times 336{,}000 = 16{,}800$ J; the water can give $0.3 \times 4{,}200 \times 40 = 50{,}400$ J cooling to 0 °C, more than enough, so all the ice melts. **[3]**

Heat lost = heat gained: $0.3 \times 4{,}200 \times (40 - T) = 16{,}800 + 0.05 \times 4{,}200 \times T$

$50{,}400 - 1{,}260T = 16{,}800 + 210T \Rightarrow 1{,}470T = 33{,}600 \Rightarrow T \approx 22.9$ °C

Marking scheme

- Heat to melt ice 16,800 J, less than 50,400 J: all melts.
- Heat lost = heat gained, with mL + msT for the ice.
- T ≈ 22.9 °C.

20. $I_g = 2\ \text{mA} = 0.002$ A **[3]**

$$R = \frac{V}{I_g} - G = \frac{10}{0.002} - 50 = 5{,}000 - 50 = 4{,}950\ \Omega$$

It is connected in series with the galvanometer.

Marking scheme

- I_g = 0.002 A and R = V/I_g − G.
- R = 4,950 Ω.
- Connected in series.

21. i. Equal numbers means half the original uranium is left: $\frac{N}{N_0} = \frac{1}{2}$, one half-life. Age = 4,470 million years. **[3]**

ii. Uranium-238's half-life is billions of years, so enough is left to measure in rocks billions of years old; carbon-14 dates only once-living things up to about 50,000 years.

Marking scheme

- Half the uranium left: one half-life.
- Age = 4,470 million years.
- U-238's half-life is very long; carbon-14 works only to about 50,000 years (once-living things).

Section D

3 × 4 = 12

22. i. By Chargaff's rule A = T and G = C: thymine 30%, guanine 20%, cytosine 20%. **[4]**

ii. 2,000 bases in all: A = T = 600, G = C = 400.

iii. 600 A–T pairs with 2 hydrogen bonds each and 400 G–C pairs with 3 each: $2 \times 600 + 3 \times 400 = 2{,}400$.

iv. Length $= 1{,}000 \times 0.34 = 340$ nm; turns $= 1{,}000 \div 10 = 100$.

Marking scheme

- T 30%, G 20%, C 20%.
- A = T = 600, G = C = 400.
- 2,400 hydrogen bonds.
- 340 nm and 100 turns.

23. i. A: 2, 8, 1 ($1s^2\ 2s^2\ 2p^6\ 3s^1$); B: 2, 8, 3 (… $3s^2\ 3p^1$); C: 2, 8, 7 (… $3s^2\ 3p^5$). All are in period 3. **[4]**

ii. A (sodium). Across a period the nuclear charge increases while electrons go into the same shell, so the outer electrons are pulled closer; A, with the smallest nuclear charge, is largest.

iii. AC (NaCl); ionic (electrovalent) bond, since A loses one electron and C gains one.

iv. Amphoteric (Al_2O_3 reacts with both acids and bases).

Marking scheme

- Configurations 2,8,1; 2,8,3; 2,8,7 and period 3.
- A is largest: least nuclear charge pulling the same shell.
- AC (NaCl), ionic bond.
- B's oxide is amphoteric.

24. i. It bends, with brass on the outside of the curve, because brass expands more than iron. **[4]**

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ii. At the set temperature the strip bends away from its contact, breaking the circuit, so the heater turns off; when it cools it straightens, touches again and the heater comes back on.

iii. It bends the other way, with brass on the inside, because brass also contracts more.

iv. Bigger. The whole plate expands like an enlarged photograph, so every distance on it, including the hole's width, grows.

Marking scheme

- Bends; brass outside (expands more).
- Bends off the contact, breaking the circuit.
- Bends the other way (brass inside).
- The hole grows: the whole plate expands like an enlarged picture.

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