2021 AUSTRALIAN SCIENCE OLYMPIAD EXAM

PHYSICS_ANSWERS

Multiple choice questions:

1	**A**
2	**A**
3	**D**
4	**D**
5	**B**
6	**C**
7	**B**
8	**C**
9	**A**
10	**E**

1 mark for each question

Section B: Runners

a) 2 marks total

Marks	For
1	Expression: $v_1 = \frac{2L}{t_1}$
1	Values: $v_1 = 0.16\ \text{km/min} = 2.7\ \text{m/s}$

b) 4 marks total

Marks	For
1	The distance Kara runs vs in this amount of time is 2 km more than the distance Anna runs in this same time
1	$v_2 t = L + v_1 t$ or equivalent
1	Expression: $t = \frac{t_1 t_2}{2(t_1 - t_2)}$
1	Value: $t = 50\ \text{minutes}$

c) 2 marks total

Marks	For
1	Expression: $v_2 = v_1(1/n + 1)$
1	Value: $v_K = 3.7\ \text{m/s}$

Section C: Sugar gliders

a) 2 marks total

i) Correct answer: $\frac{m_2}{m_1} = \left(\frac{l_2}{l_1}\right)^3$ out of **1.0**

Base mark 1.0	Correct equation, or correct expression for m_2 [i.e. $m_1\left(\frac{l_2}{l_1}\right)^3$]
Base mark 0.3	Dimensionally correct relationship with either fraction flipped [$\frac{m_2}{m_1} = \left(\frac{l_1}{l_2}\right)^3$] or $\frac{m_1}{m_2}$ increases with $\frac{l_1}{l_2}$
–0.2	Numbers (with or without units) subbed in

ii) Correct answer: 8800 g out of **1.0**

Base mark 1.0	Correct value up to 4 sig figs, including carried error (i.e. if the student got partial marks for (a) and subbed in values correctly)
Base mark 0.5	Part (a) dimensionally correct but no part (a) partial credit given, and values subbed in correctly
–0.2	5+ sig figs
–0.2	Wrong/no units

b) 1 mark total

Correct answer: $\frac{A_2}{A_1} = \left(\frac{l_2}{l_1}\right)^2$ out of **1.0**

Base mark 1.0	Correct equation, or correct expression for A_2 [i.e. $A_1\left(\frac{l_2}{l_1}\right)^2$]
Base mark 0.3	Dimensionally correct relationship with either fraction flipped [$\frac{A_2}{A_1} = \left(\frac{l_1}{l_2}\right)^2$] or $\frac{A_1}{A_2}$ increases with $\frac{l_1}{l_2}$
–0.2	Numbers (with or without units) subbed in

c) 3 marks total

Correct answer: 'parachute' out of **1.0**

Base mark 1.0	Correct answer (including carried error if consistent with (e) and (e) is dimensionally correct)

Correct answer: $l_1\cos(\alpha_1) = l_2\cos(\alpha_2)$ out of **2.0**

Base mark 2.0	Correct equation derived from $\frac{m_1\cos(\alpha_1)}{m_2\cos(\alpha_2)} = \frac{A_1 v_1^2}{A_2 v_2^2}$ with any of $v_1 = v_2$ or student's answers to part (a) and (c) subbed in
–1.0	Correct equation with (a) and (c) subbed in, but at least one of (a) and (c) dimensionally incorrect
–0.4	Numbers (with or without units) subbed in

d) 3 marks total

Correct answer: $\frac{m_1 \cos(\alpha_1)}{m_2 \cos(\alpha_2)} = \frac{A_1 v_1^2}{A_2 v_2^2}$ out of **1.0**

Base mark 1.0	Correct equation, even if $\alpha_2 = 45°$ subbed in
–0.2	Numbers (with or without units) subbed in (except $\alpha_2 = 45°$)

Correct answer: $\sqrt{\frac{m_2 \cos(\alpha_2)}{m_1 \cos(\alpha_1)} \frac{A_1 v_1^2}{A_2}}$ out of **1.0**

Base mark 1.0	Correct equation (including carried error from (f) if (f) dimensionally correct), even if $\alpha_2 = 45°$ subbed in
–0.2	Numbers (with or without units) subbed in (except $\alpha_2 = 45°$)

Correct answer: 13.3 m/s out of **1.0**

Base mark 1.0	Correct value up to 4 sig figs (including carried error from (f) if (f) dimensionally correct)
–0.2	5+ sig figs
–0.2	Wrong/no units

Section D: Pro-drugs

a) 3 marks total

Marks	For
1.2	Plotting points (0,20), (4,10) correctly
1.8	Reasonable sketch of exponential decay.

b) 1 mark total

Marks	For
0.25	W1 concentration would increase and peak at around the same time
0.25	W1 concentration would decrease and peak earlier
0.25	The concentration of W1 at long times would be lower but the rate of decay would be unchanged.
0.25	The concentration of W1 at long times would be lower, it would be decaying more rapidly

c) 2 marks total

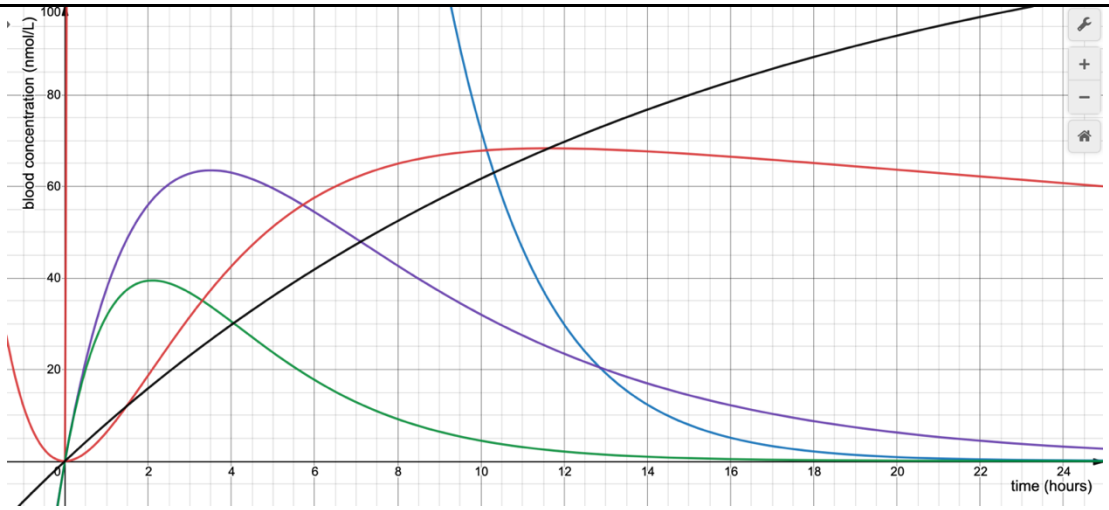
Marks	For
1	Sketch very similar to W1 curve, with matching timing.
1	Maximum is at around 60 nmol/L, scale marked clearly.

d) 2 marks total

+ 0.25 for each correct answers to (i) – (iv)

+ 1 for explanations, spread over questions, meaning that an excellent explanation for just one part may gain 0.5 marks, whereas a poor explanation in two parts may get 0.25 marks.

A2, because A2 is formed before A3 and the rate of formation of A3 depends on there being A2
A3, because A3 has a lower loss rate than A2 (and the formation of A2 will decrease as P depletes, and the loss of A2 is stronger than A3
A2 being at max concentration means dA2/dt = -(0.17+0.34)A2+0.0085P=0 hence A2/P = 0.017=1/60
A3 being at max concentration means dA3/dt = -0.012A3 +0.34A2=0, so A2/A3 = 0.035=3/85



A1 – Purple, A2 – Green, A3 – Red.

e) 3 marks total

Marks	For
1	A2 curve very similar to A1, but with peak sooner and lower concentration. Passes through origin with gradient as for A1.
1	curve which passes through origin with gradient 0 at origin, peak much later, decay slower.
1	consistency between A2, A3 curves and sensible choices of scale.

f)

Marks	For
0.2	one fragment of a reasonable idea in (i) or (ii).
0.5	one reasonable idea from (i) or (ii)
1	2-3 reasonable ideas from (i) and (ii) combined
1.5	4-5 reasonable ideas from (i) and (ii) combined
2	showing some insight and having (nearly) complete response

i)

Blood concentration depends on both initial dosage and time since initial dosage
Makes a strong link between how the ratio of concentration is independent of initial dosage. (Thus depends only on time since dose)

ii)

Physically justified explanation as to why the ratio initially increases
reasonable comment on the relative decay rates of P and A2, with a comment about the effect on conc. A2 due to production from P and conversion on to further producers
Description of how the ratio asymptotes with reasoning
Description of conditions when the ratio makes a reasonable estimate - ie. it's changing relatively quickly.
Estimate (roughly from 10-24 hours, which is 5-12 decay times) of time to get somewhat close to asymptote of ratio. Method: estimate characteristic time based on 1/decay rate OR measure from graph. Time is many times one decay time for P.

Section E: Surprising shadows

a) 4 marks total

Marks	For
1	Diagram should be well labelled and it should be clear what the student is illustrating
1	Diagram should include a mirror, rays, the object and location of the shadow.
1	It should be explained by words or diagram that light is blocked from one source first then the other.
1	Student makes is clear that it is not that there is no shadow, instead now all of the wall is evenly in shadow.

b) 1 mark – mirror.

c) 3 marks total

Marks	For
1	Diagram shows the light rays, mirror, direct shadow and mirror shadow and the virtual image. Correct ray optics is used (straight lines).
1	Diagram clearly shows two shadows for both the object and the virtual image.
1	Diagram shows which shadows are blocked by the object and which are observed

d) 3 marks total

Marks	For
1	Answer clearly shows where light is coming from.
1	Answer explains why the shadow on the mirror side is darker.
1	Answer explains that the light is a combination of the two light sources: explaining that the shadows are still lit up by one of the two light sources.

Section F: Double glazing

a 5 marks total

i) 0.5 per factor = 1 mark. Possible factors include: distance between glass sheets, air pressure between glass sheets, thickness of glass sheets, properties of supports: number, material/density, placement.

ii) 4 marks total

Marks	For
1	Must identify which factor is being changed, and how (e.g. increments). Example: five different double glazed windows constructed with an increasing distance between glass sheets by constant increment from 5mm to 20mm.
1	Must identify how they are measuring sound transmission Example: the window inserted as one face of a soundproof room, playing a constant sound recording from a speaker on the outside of the window, and a microphone on the other recording the amplitude of the sound
2	Good experimental design, including how many data points, what they keep consistent across trials, methods for error reduction, etc. Examples: 5+ data points, placing the speaker and microphone close to the glass, using the same setup each time, reducing background noise/soundproofing the room, playing a consistent sound each time, etc

b. 4 marks total

i) 1 mark total

Marks	For
1	The student makes a strongly justified link between the time measured with different windows to their heat flow rate
0.5	The student links the time measured with different windows to their heat flow rate
0	The student does not make a valid connection between the measurements and window heat flow rate

ii) 3 marks total

Marks	For
0.5	The student provides physically reasonable sources of error
0.5	The student's sources of error are a large contributor to the total error and reasonable justification is given.
1	The student's sources of error demonstrate excellent physical insight of the experiment proposed.
1	A total of two or more very significant sources of error are identified and clearly justified.
1	A change to the experimental design is listed with valid justification on how it would result in reduced uncertainty.

Some common responses:

- Error: Heat escaping through the fridge/gaps in the joinery between window and fridge
- Change: Add sealant between at the window joinery. Take a control measurement before the window is installed.
- Error: external conditions may cause the room to fluctuate in temperature
- Change: close and windows and blinds to insulate the room as much as possible, keep the heater on to maintain room temperature.

AUSTRALIAN SCIENCE INNOVATIONS

Australian Science Olympiads

Comments:

When marking out of 2 here:
2 - all good apart from extremely minor error e.g. missing units in intermediate step, precision a bit high but not too much

1.5 - almost all good with one error or a couple of small ones, e.g. some missing units and precision errors or one bit of nonsense.

1.0 - half(ish) good

0.5 - something good

0 - all nonsense or blank

Similarly when marking out of 1 here:
1 - almost complete valid answer
0.5 - some good work but could be more
0 - not substantial good work