

8th International Junior Science Olympiad
Durban, South Africa

Theoretical Examination: Part 1 - Biology
Model Answers

5 December 2011

Complete the following:

NAME:	
SEAT NO.:	
COUNTRY:	
SIGNATURE:	

This answer sheet consists of 7 pages. Please ensure you have them all.

QUESTION 1

- (a) Match the parts indicated by A, B and C (from Figure 1) in Column X with one corresponding structure or part indicated by numerals in Column Y. Write the numeral from Column Y in the space provided in Column X.

Column X	Column Y
A. III...	I. Liquid which serves as shock absorber.
B. I.....	II. Liquid which contains red blood cells to carry oxygen.
C. VIII..	III. Structure which represents the stage of human development from 3-9 months during pregnancy.
	IV. A structure which represents the stage of human development from 1-2 months during pregnancy.
	V. Structure which dilates during first stage of birth/parturition.
	VI. Site where fertilization takes place.
	VII. Structure which is shed during menstruation.
	VIII. Myometrium (Muscular wall).

(1.5 marks)

- (b) State whether the following is true or false by placing a tick (✓) in the appropriate box.

Amniocentesis cannot be carried out during the 36th week of pregnancy because...

	True	False
(i) ... the amniotic fluid will not contain cells. (0.25 mark)		<input type="checkbox"/>
(ii) ...there is a greater possibility of injuring the foetus. (0.25 mark)	<input type="checkbox"/>	

(0.5 mark)

(c)

- (i) Circle the letter which corresponds to symptom(s) of the genetic disorder which can be detected using the chromosomal map in Figure 2. (0.5 mark)

- A. Lacks or has inadequate presence of clotting factor VIII.
 B. Low muscle tone, intellectual disability and short stature
 C. Sticky mucus blocks air passages in lungs.

- (ii) True False (0.25 marks)

- (iii) Circle the correct LETTER.

- A. female because it has 23 pairs of chromosomes.
 B. male because it has 23 pairs of chromosomes.
 C. male because it has identical sex chromosomes.
 D. female because it has identical sex chromosomes.

(0.5 mark)

- (d) Answer the questions by placing a tick (✓) in the most appropriate box.

		M	N	O	P
(i)	The hormone which is released in large quantities by the pituitary gland to facilitate the process of child birth/parturition is...	<input type="checkbox"/>			
(ii)	The hormone which is produced in large quantities by the placenta and helps to maintain the endometrium is ...				<input type="checkbox"/>

(0.5 X 2 = 1mark)

QUESTION 2

Write the two correct letters which correspond to the statements.

 B/C (0.75 mark) **C/B** (0.75 mark)

QUESTION 3

Tick the appropriate box.

	True	False
A. A further increase in light intensity beyond point (c) in Figure 3a will significantly increase the rate of photosynthesis. (0.25 mark)		<input type="checkbox"/>
B. In figure 3a, beyond point (c) light intensity is the limiting factor on the rate of photosynthesis. (0.25 mark)		<input type="checkbox"/>

C. In both figures, the plant is only respiring and not photosynthesizing at point (a). (0.25 mark)		<input type="checkbox"/>
D. The plant has reached maximum rate of O ₂ production at point (d) in Figure 3b and the rate of photosynthesis may remain at a constant level. (0.25 mark)	<input type="checkbox"/>	

(1 mark)

QUESTION 4

(a)

Calculate the net energy yield for crop A	(0.25 mark)
Net energy yield: A (Wheat) = gross energy yield – energy input $= 85 \text{ GJ/hect/yr} - 30 \text{ GJ/hect/yr}$ $= 55 \text{ GJ/hect/yr}$	

Calculate the net energy yield for crop B	(0.25 mark)
Net energy yield: B (Sugarbeet) = gross energy yield – energy input $= 130 \text{ GJ/hect/yr} - 65 \text{ GJ/hect/yr}$ $= 65 \text{ GJ/hect/yr}$	

Calculate the net energy yield for crop D	(0.25 mark)
Net energy yield: D (Leycrops) = gross energy yield – energy input $= 75 \text{ GJ/hect/yr} - 25 \text{ GJ/hect/yr}$ $= 50 \text{ GJ/hect/yr}$	

Calculate the net energy yield for crop E	(0.25 mark)
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$$\begin{aligned}
 \text{Net energy yield: E (Maize)} &= \text{gross energy yield} - \text{energy input} \\
 &= 125 \text{ GJ/hect/yr} - 35 \text{ GJ/hect/yr} \\
 &= 90 \text{ GJ/hect/yr}
 \end{aligned}$$

- (b) Write the LETTER of the crop which produces the highest yield of biogas **E** _____
(0.25 mark)

(c)

LETTER of crop from non-gas biofuels which yield highest net energy.	ANSWER: <u>B</u> (0.5 mark)
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(d)

(i)

If diesel is replaced with biodiesel, calculate the estimated percentage reduction in CO₂ emissions. (1 mark)

$$\begin{aligned}
 &78 - 30 \\
 &= 48 \times 100 \\
 &\quad 78 \\
 &= 60\% \\
 &\text{Accept range } 55\% - 65\%
 \end{aligned}$$

- (ii) Place a tick in the appropriate box to choose the biofuel which is most favourable in reducing CO₂ emissions.

(0.5 mark)

Biodiesel	Biogas	Ethanol	Methanol
	<input type="checkbox"/>		

End of Biology Questions

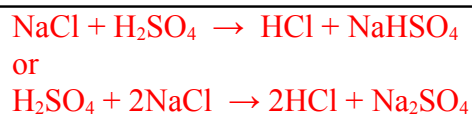
8th International Junior Science Olympiad
Durban, South Africa

Theoretical Examination: Part 1 – Chemistry
Model Answers

QUESTION 1

1.1 (0.5 marks)

Give the balanced equation:



1.2 (0.5 marks)

Insert the letter of the correct choice in Table 1.

Table 1:

NaCl is a solid at room temperature which melts at 804 °C.	C
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1.3

(i) (0.25 mark)

Formula	Circle the correct choice
HF 1/16	strong / weak 1/16
HCl 1/16	strong / weak 1/16

(ii) (1.25 marks = 5 x 0.25)

Statement Number	Circle the correct choice
1.	True / False
2.	True / False
3.	True / False
4.	True / False
5.	True / False

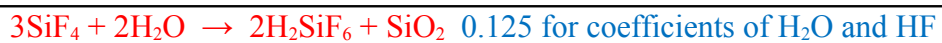
1.4 (0.75 mark)

Formula of A	SiF ₄ 0.25
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Formula of B

H₂O 0.25

Give the balanced equation:



1.5 (0.5 mark = 0.1 × 5)

	Mixture	Circle the correct choice
A	HCl + H ₂ SO ₄	Yes / No
B	HF + H ₂ O	Yes / No
C	HF + NaF	Yes / No
D	HF + excess NaOH	Yes / No
E	HCl + excess NaOH	Yes / No

1.6 (1 mark)

Calculation of the number of H⁺ ions present in one drop (0.05 cm³) of water.

Show K_w expression or pH 7 (0.25 mark)

Conc of H⁺ in water = $1.0 \times 10^{-7} \text{ mol dm}^{-3}$ (0.25 mark)

moles of H⁺ = $1.0 \times 10^{-7} \text{ mol dm}^{-3} \times 0.050 \text{ mL} \times 10^{-3} = 5.00 \times 10^{-12} \text{ mol}$ (0.25 mark)

no. of H⁺ ions = $5.00 \times 10^{-12} \text{ mol} \times 6.022 \times 10^{23} \text{ mol}^{-1} = 3.0 \times 10^{12}$ (0.25 mark)

(minus 0.125 for missing conversion, final answer, etc.)

QUESTION 2

2.1 (1 mark)

(i) Give the letter of the statement that correctly completes the sentence:

Statement	A	<i>(0.25 mark)</i>
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(ii) Give the letter of the statement that correctly completes the sentence:

Statement	C	<i>(0.5 mark)</i>
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(iii) Give the letter of the statement that correctly completes the sentence:

Statement	D	<i>(0.25 mark)</i>
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2.2 (0.5 mark)

Calculation of the pH of $0.25 \text{ mol dm}^{-3} \text{ H}_2\text{SO}_4$ at 25°C .



$$\text{pH} = -\log(0.5) = 0.30 \quad (0.25) \quad \text{minus } 0.125 \text{ for any mistake}$$

2.3 (0.5 mark)

Calculation of the volume to which 75.0 cm^3 of a $10.0 \text{ mol dm}^{-3} \text{ H}_2\text{SO}_4$ solution should be diluted to obtain a $1.75 \text{ mol dm}^{-3} \text{ H}_2\text{SO}_4$ solution.

No. of moles of H_2SO_4 before dilution = No. of moles of H_2SO_4 after dilution

$$(\text{M H}_2\text{SO}_4 \times \text{vol H}_2\text{SO}_4)_{\text{before dilution}} = (\text{M H}_2\text{SO}_4 \times \text{vol H}_2\text{SO}_4)_{\text{after dilution}}$$

$$10.0 \text{ M H}_2\text{SO}_4 \times 75.0 \text{ mL} = 1.75 \text{ M H}_2\text{SO}_4 \times \text{vol of H}_2\text{SO}_4 \quad (0.25 \text{ mark})$$

$$\text{vol of H}_2\text{SO}_4 = 429 \text{ mL} \quad (0.25 \text{ mark})$$

minus 0.125 for any mistake

2.4 (0.75 mark)

Calculation of the volume of $0.101 \text{ mol dm}^{-3} \text{ NaOH}$.



$$\text{Moles of H}^+ = 0.138 \text{ M H}_2\text{SO}_4 \times 10.0 \text{ mL} \times 2 = 2.76 \times 10^{-3} \text{ mol} \quad (0.25 \text{ mark})$$

$$\text{Volume of NaOH} = (2.76 \times 10^{-3} \text{ mol} / 0.101 \text{ mol dm}^{-3}) \times 10^3 = 27.3 \text{ mL} \quad (0.25 \text{ mark})$$

Answer required in cm^3

Minus 0.125 for any mistake

(1 mark)

	Equation for half-reaction
Anode or positive electrode	$2\text{H}_2\text{O} \rightarrow 4\text{H}^+ + \text{O}_2$ (0.5 mark) OH^- not accepted as reactant
Cathode or negative electrode	$2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$ (0.5 mark) water not accepted as reactant

2.5 (1.75 marks)

Calculation of the density of SO_2 .
$d = \frac{pM}{RT} = \frac{(1.464 \times 10^{-4} \text{ atm})(101325 \text{ Pa atm}^{-1})(64.07 \text{ g mol}^{-1})}{(8.314 \text{ J K}^{-1} \text{ mol}^{-1})(191.95 \text{ K})} = 0.596 \text{ g m}^{-3}$
$n = pV/RT = (1.2 \text{ atm} \times 101325 \text{ Pa})(500 \text{ dm}^3 \times 10^{-3}) / (8.314 \text{ J K}^{-1} \text{ mol}^{-1})(304.35 \text{ K}) = 24.026 \text{ mol} \quad (0.5 \text{ mark})$
$V_2 = nRT/p = [(24.026 \text{ mol})(8.314 \text{ J K}^{-1} \text{ mol}^{-1})(191.95 \text{ K})] / (0.000122 \times 101325 \text{ Pa} \times 1.2 \text{ atm}) = 2585 \text{ m}^3 \quad (0.5 \text{ mark})$
$\text{Molar mass} = 32.06 + 32.00 = 64.06 \text{ g mol}^{-1} \quad (0.25 \text{ mark})$
$\text{Mass} = 24.026 \text{ mol} \times 64.06 \text{ g mol}^{-1} = 1539 \text{ g} \quad (0.25 \text{ mark})$
$\text{Density} = m/V = 1539 \text{ g} / 2585 \text{ m}^3 = 0.595 \text{ g m}^{-3} \quad (0.25 \text{ mark})$
(Minus 0.125 for errors)

End of Chemistry Answers

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Theoretical Examination: Part 1 – Physics

Model Answers

□=0.5 point

Question 1

(a) (i)

(0.5 point)

real	virtual	magnified	diminished
□		□	

(ii) **(0.5 point)**

There will be no image	You will only see the bottom half of the filament	You will only see the top half of the filament	You will still see the full image of the filament
			□

(iii) **(0.5 point)**

There will be no image of the filament	You will see a larger image of the filament	You will see an upright image of the filament	You will see a faint image of the filament
□			

(b)

30 cm

50 cm

16 cm

$s = -14 \text{ cm}$ □ for diverging lens.

$s' = 50 - 16 \text{ cm} = 34 \text{ cm}$ □

Using the thin lens equation, we have

$$1s + 1s' = 1f \Rightarrow \mathbf{1 - 14 \text{ cm} + 134 = 1f}$$

$$\Rightarrow 1f = -0.0420 \text{ cm}^{-1}$$

$$\mathbf{f = -24 \text{ cm}}$$
 □

(2 points)

Question 2

(1.5 points)

(a) $N - mg = mv^2/R$

(b) $\Rightarrow N = mv^2/R + mg = 50 \text{ kg} (2\pi \cdot 35 \text{ m} / 50 \text{ s})^2 / 35 + 9.8 \text{ ms} = 518 \text{ N}$

(c) (b)

(d) (2 point)

(e) $FL_2 = mv^2(L_1 + L_2) = m^2 \pi^2 (L_1 + L_2)^2 T^2 (L_1 + L_2) = 4\pi^2 m (L_1 + L_2)^2 T^2$

(f) $FL_1 - FL_2 = mv^2 L_1$

(g) $\Rightarrow FL_1 = m^2 \pi^2 L_1 T^2 L_1 + 4\pi^2 m (L_1 + L_2)^2 T^2 = 4\pi^2 L_1 T^2 + 4\pi^2 m (L_1 + L_2)^2 T^2 = 4\pi^2 m (2L_1 + L_2)^2 T^2$

(h)

(i)

(j)

(k)

(l)

(m)

(n)

(o)

(p)

(q)

(r)

(s) Question 3

(t) (a)

(u) (1 point)

(v) $12mv^2 = 9.6 \times 10^{-13} \text{ J}$

(w) $v = 3.4 \times 10^7 \text{ ms}$

(x)

(y)

(z) (2 point)

(aa) Consider part of the beam as a cylinder with cross section area A .

(bb) N = number of protons per unit volume

(cc) In time Δt , each proton moves a distance $v\Delta t$

(dd) V = Volume of beam = $Av\Delta t$

(ee) Charge ΔQ flowing out of the cylinder in time Δt is

(ff) $\Delta Q = qpNAv\Delta t$

(gg) Current is $I = \Delta Q / \Delta t = qpNAv$

(hh) $N = I / qpAv$

(ii) $= 800 \times 10^{-6} \text{ A} / (1.6 \times 10^{-19} \text{ C} \times \pi \cdot 1.5 \times 10^{-3} \text{ m}^2 \times 3.4 \times 10^7 \text{ ms})$

(jj) $= 1.6 \times 10^{13} \text{ protons/m}^3$

(kk)

(ll)

(mm)

(nn)

(oo)