NSAA 2016
Section 1

Model Solutions

1. $-8 < 6 - \frac{x}{2}$

$-16 < 12 - x$

$x - 16 < 12$

$x < 28 \Rightarrow G$

2. $(\sqrt{3} - \sqrt{2})^2$

$= 3 - 2\sqrt{3}\sqrt{2} + 2$

$= 5 - 2\sqrt{6}$ or $= 5 - 2\sqrt{2}\sqrt{3}. \Rightarrow B.$

3.

$Q = \frac{5}{2} R$

$R = \frac{3}{10} S$

$Q = \frac{5}{2} \cdot \frac{3}{10} S$

$= \frac{15}{20} S$

$= \frac{3}{4} S$

$\Rightarrow Q : S = 3 : 4 \Rightarrow C.$

4. Sum of ages $= 20 \times 28 = 560.$

New Sum of ages $= 22 \times 30 = 660.$

Hence Sum of two new members $= 660 - 560 = 100.$

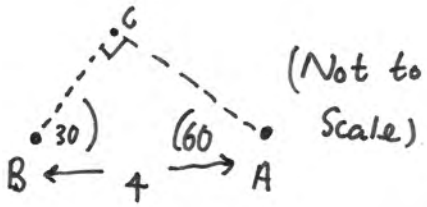
Hence mean age $= \frac{100}{2} = 50$ years. $\Rightarrow E.$

5. After first year value $= 0.8 \times 15000 = 12000$

After Second year value is $0.8 \times 12000 = 9600.$

Hence, total lost in value $= £15000 - £9600 = £5400. \Rightarrow C.$

6.



Hence using Simple trigonometry we can deduce:

$$\cos 30° = \frac{BC}{4}$$

$$\Rightarrow BC = 4\cos 30°$$

$$= 2\sqrt{3}\ \text{km}.$$

$\Rightarrow$ B.

7. $$x = \frac{k}{\sqrt{y}}$$

$$8 = \frac{k}{\sqrt{9}} \Rightarrow k = 24.$$

$$6 = \frac{24}{\sqrt{y}}$$

$$\Rightarrow \sqrt{y} = 4 \Rightarrow y = 16. \Rightarrow F.$$

8. $$\text{area} = \frac{(x-1)+(x+5)}{2} \times x$$

$$= \frac{2x+4}{2} x$$

$$= x^2 + 2x.$$

$$= 120.$$

$$x^2 + 2x - 120 = 0$$

$$(x+12)(x-10) = 0.$$

as $x > 0$ (it is a length).

$$\Rightarrow x = 10.$$

$$\Rightarrow RS = 10 + 5 = 15\text{cm}. \Rightarrow E.$$

9.

$$a = \frac{b^2+2}{3b^2-1}$$

$$a(3b^2-1) = b^2+2.$$

$$3b^2a - a = b^2+2$$

$$b^2(3a-1) = a+2.$$

$$b^2 = \frac{a+2}{3a-1}$$

$$\Rightarrow b = \pm\sqrt{\frac{a+2}{3a-1}} \Rightarrow B.$$

10. We know that the circumference is $5m$.

$$\pi d = 5$$

So, the area of the top circular face:

$$\frac{\pi d^2}{4} = \frac{(\pi d)^2}{4\pi} = \frac{25}{4\pi}.$$

Hence the volume $= \frac{25}{4\pi} \times 10 = \frac{250}{4\pi} = \frac{125}{2\pi} m^3. \Rightarrow C.$

11.

$$4 + \frac{4-x^2}{x^2-2x}$$

$$= 4 + \frac{(2-x)(2+x)}{x(x-2)}$$

$$= 4 + -\left(\frac{2+x}{x}\right)$$

$$= 4 - 1 - \frac{2}{x} = 3 - \frac{2}{x} \Rightarrow A.$$

12.

	Boys	Girls	Tot.
Swim	32	25	57
Archery	18	9	27
Tennis	24	12	36
Tot.	74	46	120

P(of a randomly Selected boy, he chose Swimming)

$= \frac{32}{74}$

$= \frac{16}{37}$ => D.

13.

$9^{2n+1} = (3^2)^{2n+1} = 3^{4n+2}$.

$27^{2-n} = (3^3)^{2-n} = 3^{6-3n}$.

$$\Rightarrow \frac{9^{2n+1} \times 3^{4-3n}}{27^{2-n}} = \frac{3^{4n+2} \times 3^{4-3n}}{3^{6-3n}} = \frac{3^{n+6}}{3^{6-3n}} = 3^{4n}. \Rightarrow D.$$

14. Exterior angle of the polygon $= \frac{360°}{n} = \angle RQT = \angle RTQ$.

Hence, $x = 180 - 2\left(\frac{360}{n}\right) = \frac{180n - 720}{n}$.

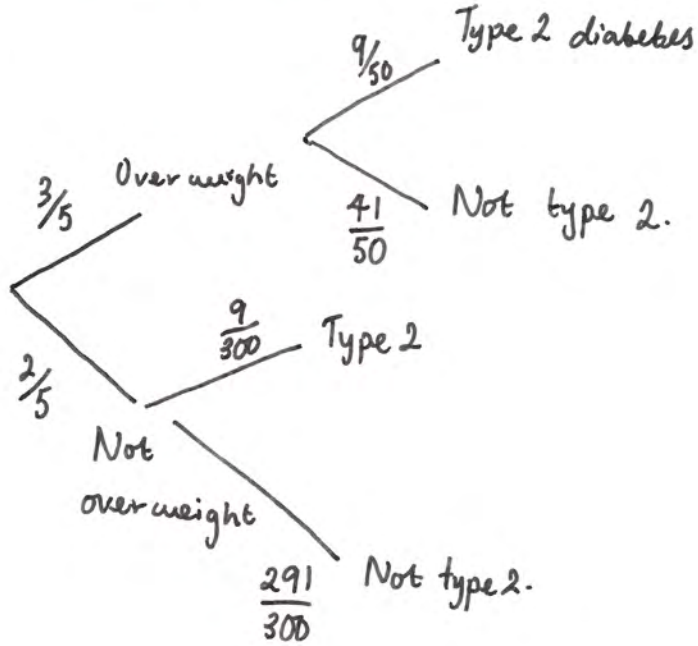
Rearranging:

$$nx = 180n - 720$$

$$n(x - 180) = -720$$

$$n = \frac{-720}{x - 180} = \frac{720}{180 - x} \Rightarrow E.$$

15.



$$\left(\frac{3}{5} \times \frac{9}{50}\right) + \left(\frac{2}{5} \times \frac{9}{300}\right)$$

$$= \frac{27}{250} + \left(\frac{2}{5} \times \frac{3}{100}\right)$$

$$= \frac{27}{250} + \frac{6}{500}$$

$$= \frac{60}{500} = \frac{3}{25} \Rightarrow B.$$

16.

$x^2 + ax + b = x + 1$.

$2^2 + a \times 2 + b = 2 + 1$ $\quad 4^2 + 4a + b = 5$

$\Rightarrow 4 + 2a + b = 3$ $\quad (\beta)\ 4a + b = -11$

$(\alpha)\ 2a + b = -1$.

$(\beta) - (\alpha)$: $2a = -10$

$\Rightarrow a = -5$

$4a + b = -11$

$-20 + b = -11$

$\Rightarrow b = 9$.

$a = -5,\ b = 9. \Rightarrow A$.

17.

$x = \frac{\sqrt{5^2 + 3^2}}{2}$

$= \frac{\sqrt{25 + 9}}{2}$

$= \frac{\sqrt{34}}{2}$ $\Rightarrow$ $\frac{\sqrt{68}}{\left(\frac{\sqrt{34}}{2}\right)} = 2\sqrt{2}$.

$\Rightarrow$ Sides will be enlarged by Scale factor of $2\sqrt{2}$. $\Rightarrow C$.

$\Rightarrow$ Diagonals must be extended/enlarged by Scale factor of

18.

$m = \frac{-1 - (1 - p)}{2p + 1 - 7} = \frac{p - 2}{2p - 6}$. to be greater than 0, $p < 2$, $p > 3$.

and, to be finite we require $p > 3$ NOT $p \geq 3$.

$\Rightarrow F$.

19. Microwaves have larger wavelengths than gamma rays.
Hence the wavelength has increased, but, then the frequency must have decreased as $c = f\lambda$. => B.

20. Try to construct the decay equation:

$$^{214}_{82}Pb \rightarrow {}^{210}_{82}Pb + {}^{4}_{2}\alpha + 2\,{}^{0}_{-1}\beta.$$

Hence one alpha and two beta. => D.

21. Rate of conduction $\propto$ difference in temperature.
Rate of conduction $\propto$ to A, $\propto$ to l^{-1}.
The only row where, given the above conditions, the rate of conduction remains the Same is row H. This is because A and l do not change and neither does the temperature difference.

22. 1 is wrong because $E_K = \frac{m}{2}v^2 \propto v^2$ and so the graph will NOT be a Straight line.
2, is wrong because potential energy (gravitational) = $mg\Delta h$.
when $\Delta h = 2$, $GPE = 20 \times 10 \times 2 = 400J \neq 10$.

3. $F = ma$

$100 = 20a \Rightarrow a = 5\ ms^{-2}$.

Hence after 2.0 seconds, velocity $= 5 \times 2.0 = 10$ m/s. So, 3 is possible.

4. Work = force × distance

$= 5 \times 2$

$= 10$ J.

Work is proportional to distance for a constant force hence 4 is possible.

$\Rightarrow$ Answer is F.

23. Need to look for conservation of charge and mass number:

In diagram 1, looking at charge numbers:

$$\underbrace{1 + 92}_{93} \rightarrow \underbrace{56 + 36}_{92}$$

$\Rightarrow$ diagram 1 is not possible.

In diagram 2, looking at mass numbers:

$$\underbrace{1 + 235}_{236} \rightarrow \underbrace{137 + 96 + 3}_{236}$$

$\Rightarrow$ conserved

looking at proton numbers:

$0 + 92 \rightarrow 54 + 38$ $\Rightarrow$ conserved.

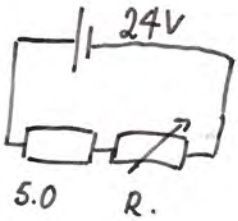
In diagram 3, looking at mass numbers:

$\underbrace{1 + 235}_{236.} \rightarrow \underbrace{87 + 145 + 3}_{235}$ => not conserved

Hence only diagram 2 is possible.

=> C.

24.



$I = \frac{24}{5.0 + R}$

=> Power dissapated in 5.0 Ω resistor

$= I^2 \text{ f} \times \text{resistance}$

$= \left(\frac{24}{5.0+R}\right)^2 \times 5.0$

(maximum with $R = 3.0\ \Omega$)

$= \left(\frac{24}{8}\right)^2 \times 5$

$= 9 \times 5$

$= 45\text{W}$. => D.

25.

Current before:

equivalent resistance $= \left(\frac{1}{30+30} + \frac{1}{30}\right)^{-1} = \left(\frac{1}{60} + \frac{2}{60}\right)^{-1} = 20\ \Omega.$

current $= \frac{V}{R} = \frac{12}{20} = \frac{3}{5} = 0.60\text{A}.$

Current after Switch is closed:

$$\text{equivalent resistance} = \left(\frac{1}{30} + \frac{1}{30}\right)^{-1} = 15\,\Omega.$$

$$I = \frac{V}{R} = \frac{12}{15} = \frac{4}{5} = 0.80\,A.$$

$\Rightarrow$ current has gone up by $0.20\,A$.

$\Rightarrow E$

26. Let initial radius be R, initial temperature be T, initial power P_0.

$$P_0 = kR^2T^4.$$

Then, new power, $P_1 = k(100R)^2\left(\frac{T}{2}\right)^4$

$$= \frac{10000}{16} kR^2T^4$$

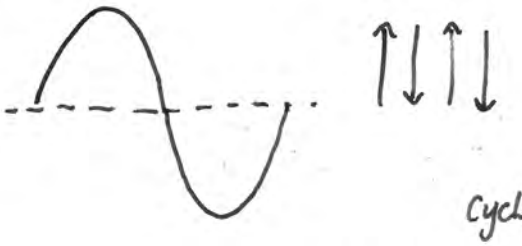
$$= \frac{10000}{16} P_0.$$

$$= \frac{10000}{16} \times 4.0 \times 10^{26}$$

$$= \frac{1}{4} \times 10^{30}$$

$$= 2.5 \times 10^{29} \Rightarrow D.$$

27.

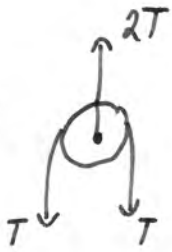


particle travels the amplitude four times per cycle.

Cycles in one minute $= 5.0 \times 60 = 300$.

$\Rightarrow$ distance $= 4 \times 3.0 \times 300 = 12 \times 300 = 3600$ cm. $\Rightarrow E$.

28. Needs to withstand twice the tension is the rope:



To accelerate at $0.80\ m/s^2$ we need:

$$T - 5g = 5 \times 0.8$$
$$T = 5g + 4$$
$$= 54N.$$

Hence coupling must withstand at least 108N.

$\Rightarrow$ H.

29. Current through heater $= \frac{6.0V}{15\Omega} = \frac{2}{5} = 0.4A.$

$\Rightarrow$ charge in 3 minutes $= 0.4A \times 3 \times 60$

$= 1.2 \times 60$

$= 72C.$

Also we know $E = QV = 180J$

$$\Rightarrow V = \frac{180}{Q} = \frac{180}{72} = \frac{30}{12} = 2.5V.$$

$\Rightarrow$ charge = 72C, voltage = 2.5V $\Rightarrow$ F.

30. Volume of block $= 10^3 - 5^2 \times 10 = 1000 - 250 = 750\ cm^3$

$$\text{mass} = \frac{30N}{10N\,kg^{-1}} = 3kg = 3000g.$$

$$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{3000}{750} = 4\ g\,cm^{-3} \Rightarrow F.$$

31. Convection will be when temperature difference between balls and the room is greatest. (and non 0) Hence P and Q will lose thermal energy by convection.

Greatest rate of thermal emmision is from highest temperature ball and dullest surface => S.

Hence we have D is the correct answer.

32. Total distance $= \left(\frac{20 \times 8}{2}\right) + \left(\frac{10 \times 2}{2}\right) = \frac{160}{2} + \frac{20}{2} = 90m.$

Distance from Starting position $= \left(\frac{20 \times 8}{2}\right) - \left(\frac{10 \times 2}{2}\right)$

$= 80 - 10$

$= 70m.$

Average Speed $= \frac{\text{distance}}{\text{time}} = \frac{90m}{30s} = 3.0\ m/s. \Rightarrow A.$

33.

E is wrong because initially, number of $Y = 0$.

C is wrong because Y will decay also i.e. its number will eventually decrease.

D is wrong because it suggests the half life of Y is less than X.

B is wrong because the maximum value of Y is (as portrayed on graph)

greater than the initial value of X. This cannot be true because one nuclei of X turns into at most one nuclei of Y. Hence A is the only valid option.

34. Let a volume of bronze = V.

Then volume of tin = $\frac{V}{10}$ and its mass = $\frac{YV}{10}$.

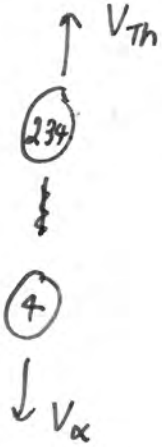
Then volume of copper = $\frac{9V}{10}$ and its mass = $\frac{X9V}{10} = \frac{9VX}{10}$.

=> percentage of Sample which is tin = $\frac{\frac{YV}{10}}{\frac{9VX}{10} + \frac{YV}{10}} \times 100$

$= \frac{Y}{9X + Y} \times 100$

=> G.

35.



Conservation of momentum:

$234V_{Th} = 4V_\alpha$

$V_{Th} = \frac{4}{234} V_\alpha$

We know: $\frac{1}{2} m_\alpha V_\alpha^2 + \frac{1}{2} m_{Th} V_{Th}^2 = E$

$m_\alpha V_\alpha^2 + m_{Th} V_{Th}^2 = 2E$

$$m_\alpha v_\alpha^2 + \left(\frac{234}{4} m_\alpha\right)\left(\frac{4v_\alpha}{234}\right)^2 = 2E$$

$$m_\alpha v_\alpha^2 + m_\alpha v_\alpha^2 \cdot \frac{4}{234} = 2E$$

$$m_\alpha v_\alpha^2 \left(1 + \frac{4}{234}\right) = 2E$$

$$\frac{1}{2} m_\alpha v_\alpha^2 = \frac{234}{238} E. \Rightarrow D.$$

36. We need both echoes to arrive at the time of the next click.

t_1 = time for pulse to travel to the building on the left and back.

t_2 = time for pulse to travel to the building on the right and back.

$$t_1 = \frac{96}{320} \qquad t_2 = \frac{160}{320}$$

We need whole numbers of clicks in t_1 and t_2 such that the times are equal i.e.

$$3 \times \frac{160}{320} = 5 \times \frac{96}{320}.$$

Then, each pulse will have completed an integer number of journeys.

So we have 5 clicks within t_2 and 3 within t_1.

$$\Rightarrow T = \frac{\left(\frac{160}{320}\right)}{5} = \frac{\left(\frac{96}{320}\right)}{3} = \frac{32}{320} = 0.1s \Rightarrow f = 10Hz. \Rightarrow G.$$

NSAA 2016 section 1: PART C Chemistry

37.

$^{40}_{20}Ca^{2+}$ has 20 neutrons, 18 electrons

A $^{35}_{17}Cl^-$ has 18 neutrons, 18 electrons ✗

B $^{37}_{17}Cl$ has 20 neutrons, 17 electrons ✗

C $^{40}_{18}Ar$ has 22 neutrons, 18 electrons ✗

D $^{39}_{19}K^+$ has 20 neutrons, 18 electrons ✓

E $^{39}_{19}K$ has 20 neutrons, 19 electrons ✗

Answer is D.

38.

1 Titanium atoms have 2 electrons in their outer shell so it is not full, and therefore not nobel gas configuration.

2 Titanium oxide exists in an ionic lattice, so when molten the ions become mobile and can move to conduct charge.

3 Ti = 7.2g O_2 = 3.6dm^3

$\frac{7.2}{48} = 0.15$ moles $\frac{3.6}{24} = 0.15$ moles

0.15 : 0.15

1 : 1 $\Rightarrow TiO_2$ Answer is D

39.

1 Covalent in O_2 broken, ionic between Na and O formed

2 Covalent in H_2O broken, covalent in H_2 and Cl_2 formed

3 ionic in Fe_2O_3 broken, ionic in Al_2O_3 formed

Answer is C

40.

↑ in temp ↑ yield, indicating that the forward reaction is endothermic.

↑ in pressure has no effect on yield, indicating that there are the same number of moles on each side.

Answer is C.

41.

Br = 1.6g O = 2.4 − 1.6 = 0.8g

$\frac{1.6}{80}$ = 0.02 moles of Br

$\frac{0.8}{16}$ = 0.05 moles of O

0.02 : 0.05

1 : 2.5

2 : 5 ⇒ Br_2O_5

Answer is C.

42.

Sb^{3+} has 48 electrons, so Sb has 51 electrons and therefore 51 protons.

Atomic mass of isotope 1:

70 + 51 = 121

Atomic mass of isotope 2:

72 + 51 = 123

Relative atomic mass:

$\left(121 \times \frac{60}{100}\right) + \left(123 \times \frac{40}{100}\right) = 121.8$

Answer is D

43.

1 The distance travelled by the solvent shows the relative solubility of the component in the mobile phase, not its concentration

2 The mobile phase is the water solvent, and the filter paper is the stationary phase

3 This is correct as the rf values of the components match the rf values of W and Y

$\frac{3.2}{5} = \frac{6.4}{10} = 0.64$ Y → $\frac{6.4}{10} = 0.64$

$\frac{4.1}{5} = \frac{8.2}{10} = 0.82$ W → $\frac{8.2}{10} = 0.82$

Answer is D

44.

A Both experiments have the same number of moles of H_2O_2, so would produce the same total volume of O_2

$0.1 \times 1 = 0.1$ moles $0.05 \times 2 = 0.1$ moles

B The volume of oxygen produced would be the same

C The volume of oxygen produced would be the same

D The volume of oxygen produced would be the same as this is the catalyst

E Double the volume of oxygen would be produced as double the number of moles of H_2O_2 are used

$0.1 \times 1 = 0.1$ moles $0.025 \times 2 = 0.05$ moles

Answer is E

45.

1 $\overset{0}{Cl_2} + 2\overset{+1\,-1}{KI} \longrightarrow \overset{0}{I_2} + 2\overset{+1\,-1}{KCl}$

Cl is reduced (gains 1 electron) ⇒ redox reaction
I is oxidised (loses 1 electron)

2 $\overset{0}{Cl_2} + 2e^- \longrightarrow 2\overset{-1}{Cl}^-$

Cl is reduced (gains 1 electron)

3 $\overset{+1\,-1}{HCl} + \overset{+1\,+5\,-2}{AgNO_3} \longrightarrow \overset{+1\,-1}{AgCl} + \overset{+1\,+5\,-2}{HNO_3}$

Nothing oxidised or reduced

4 $\overset{0}{Cl_2} + \overset{+1\,-2}{H_2O} \rightarrow \overset{+1\,-1}{HCl} + \overset{+1\,+1\,-2}{HClO}$

Cl is reduced and oxidised - disproportionation
⇓
redox reaction

Answer is C.

46.

Copper (II) nitrate is $Cu(NO_3)_2$

Equation: $Cu + HNO_3 \rightarrow Cu(NO_3)_2 + X$

Balanced equation: $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 4H_2O + X$

2 N and 2 O are left over

⇓ $X = 2NO$

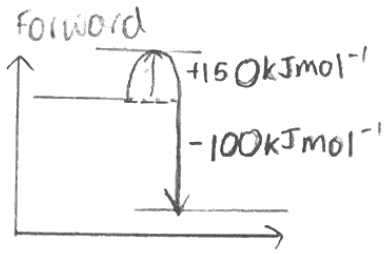
Answer is A.

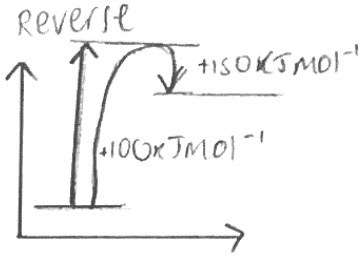
47.

We know that in the electrolysis of NaCl $Cl_2(g)$ and $H_2(g)$ form at each electrode, so we can eliminate all options which suggest another element forms or where they are recorded as having a mass rather than a volume.

This leaves C and D, and we know that chlorine is oxidised, so this therefore takes place at the anode (+ve electrode) Answer is C.

48.





$100 + 150 = 250 kJmol^{-1}$

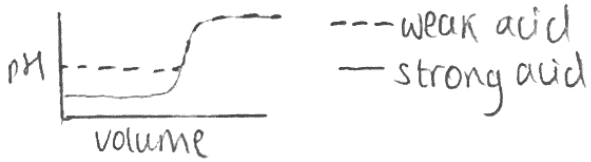
Answer is F

49.

Strong acid = completely dissociates

1 The stronger acid would react faster because there are more hydrogen ions in the solution

2 The same volume of NaOH is needed as there are the same number of moles of acid.



3 Stronger acids have greater electrical conductivity because there are more H^+ in saution

Answer is F

50.

Equation: $Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$

Moles of CO_2:

$240 cm^3 \rightarrow 0.24 dm^3$

$0.24 \div 24 = 0.01$ moles

Mass of sodium carbonate:

$0.01 \times 106 = 1.06$

Mass of impurity:

$1.50 - 1.06 = 0.44g$ Answer is A

51.

$2Li + H_2O \rightarrow Li_2O + H_2$

moles of Li:

$\frac{0.35}{7} = 0.05$

volume of H_2:

$\frac{0.05}{2} = 0.025$ moles

$0.025 \times 24 = 0.6 dm^3$

$= 600 cm^3$

Answer is F

52.

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

moles of NaOH

$0.1 \times 0.025 = 0.0025$

concentration of H_2SO_4

$\frac{0.0025}{2} = 0.00125$

$\frac{0.00125}{0.05} = 0.025 mol dm^{-3}$

$0.025 \times 98 = 2.45 g dm^{-3}$

Answer is D

53.

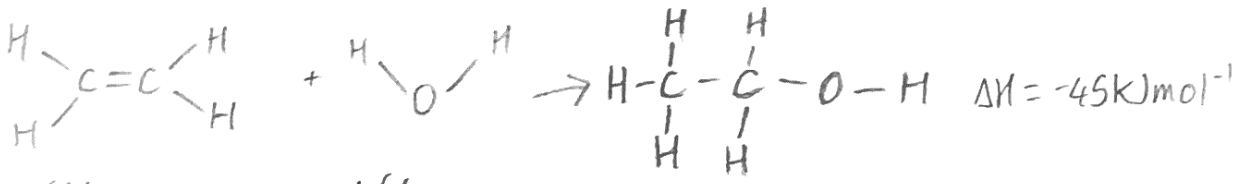
1 $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$ The e^- must be balanced so the ratio of hydrogen to oxygen is 2:1

$4H_2O + 4e^- \rightarrow 2H_2 + 4OH^-$

2 It will, as H_2O is being removed and broken down at each electrode

3 Because they will react with the equal number of moles of OH^- to form H_2O Answer is F

54.



611
413
413
413
+413
2263

464
+464
928

413
413
413
346
413
413
464
+ x
2875 + x

2263 + 928 = 3191

$3191 - 2875 - x = -45$

$316 - x = -45$

$316 + 45 = x$

$361 = x$

Answer is C.

NSAA 2016 section 1: Part D Biology

55.

1 Adaptation occurs when a selection pressure is applied which leads to the selection of a characteristic in a species that allows it to survive. Even though the copper ions were poisonous, one type of rainbow fish was able to survive indicating that the species genetic make up had changed to allow it to do this.

2 They may have showed genetic variation, but just not in the gene that could provide characteristics to allow it to survive in a copper polluted river.

3 Yes, as it caused the allele which made certain fish more likely to survive to increase in frequency within the gene pool. This is because those without it died and did not reach breeding age.

Answer is C

56.

If the surrounding solution is more concentrated then it has a lower water potential compared to the cytoplasm. Osmosis is the movement of water molecules from an environment with a higher water potential to that with a lower water potential. This indicates that water would move from the cytoplasm to the surrounding environment, and therefore water would move from the vacuole to the cytoplasm.

Answer is F

57.

1 single celled - eubacteria, euarchaea, protoctista, fungi (eliminate E, C)

2 chloroplasts - protoctist (eliminate B, D)

3 cell wall - protoctist

∴ Algae is a protoctist

Answer is A

58.

Percentage decrease:

$32 - 8 = 24$

$\frac{24}{32} = \frac{3}{4} = 0.75 \times 100 = 75\%$.

Conclusion:
Enzymes do not die in hot conditions but can no longer function because the bonds within the structure break causing it to denature.

Answer is C.

59.

As it is a recessive condition each affected individual has 2 albinism allele.

$29 \times 2 = 58$

Each symptomless carrier has 1 albinism allele.

$8200 + 58 = 81258$ Answer is E

60.

The student is working with a human enzyme which is likely to work optimally at 25°C and pH 7 as when carried out at these conditions the solution turned clear. Changing the pH or temperature is likely to denature the enzyme. Halving or doubling both the enzyme and protein solution will lead to it still taking 15 minutes. Stirring will result in a faster rate of reaction because the frequency of collisions between the enzyme and substrate will increase, leading to a greater proportion of successful collisions

Answer is B

61.

Volume of gas produced (find the volume of the cylinder the bubble moved):

$\pi \times 0.5^2 \times 16 = 4\pi$

Reason for reduction:
Enzymes are required in the light independent stage and cannot be fully occupied as the plant is underwater and no extra CO_2 is being supplied. Answer is B

62.

1 The vacuole indicates that it is a plant cell so it will also have a cell wall

2 Mitochondria are too small to be seen with a light microscope at this magnification

3 Chromosomes cannot be seen because they are not condensed as this is non dividing tissue.

Answer is B

63.

1 Yes, because the movement of auxin to the shaded side of the stem causes the cells here to elongate (at Q)

2 Yes, because upon exposure to unidirectional light auxin moves to the shaded side (Q)

3 Yes, as above. This means the concentration on the illuminated side decreases.

Answer is H

64.

As they are percentages, the percentage of base C present is

$100-(26+28+14)=32$

Due to complementary base pairing (A to T, C to G and vice versa) we can calculate the percentages in the second strand

P = 14

Q = 28

R = 32

S = 26

Answer is E

65.

	F	f
F	FF	Ff
f	Ff	ff

male with cystic fibrosis: $\frac{1}{2} \times \frac{1}{4}$

$= \frac{1}{8}$

female carrier = $\frac{1}{2} \times \frac{1}{2}$

$= \frac{1}{4}$

Answer is G

66.

Intra = within a species

4 and 5 are the only examples of competition within the same species.

Answer is E

67.

Number of strands of DNA in each sperm cell:

- As the diploid cell has 8 chromosomes the haploid cell has 4 chromosomes
- Each chromosome has 2 strands of DNA in a double helix

∴ 8 strands of DNA

Number of sperm cells produce

- meiosis of a diploid cell produces 4 haploid cells

∴ 4 sperm

Answer is D

68.

Glucose will be lower as it is used up in the muscle during respiration.

Carbon dioxide will be higher as this is a product of respiration.

Lactic acid will be higher as it is produced in anaerobic respiration.

Answer is B

69.

Females = XY Males = XX

Ratio:

5 males : 9 females

Total number of Y chromosomes:

There are 9 females and each have 1 so there must be 9.

Answer is D

70.
A Anaerobic respiration does not use oxygen
B Photosynthesis produces oxygen
C Yes, as bacteria are anaerobically respiring to break down the dead plants at the bottom of river (which have been shielded from sunlight by algae
D Bloodworms and sludgeworms respire anaerobically so will not be affected directly by low oxygen levels
E They do not compete with algae for oxygen, they compete with

Answer is C

71.
1 + 2 + 3 The same number of enzymes are present, and the concentration of substrate begins at 10, so the enzymes could already be working at their maximum rate and any increase in substrate has no further effect. Therefore the rate of substrate loss and enzyme-substrate complex formation will remain the same despite any increase in substrate concentration. The rate of product formed per enzyme molecule depends on the rate of enzyme substrate formation, so therefore remains the same.

72.
prob that after the first mutation, the first triplet does not code for arginine:
Only the insertion of G to form CGG would work
↳ 1/4 chance of this happening
$1 - 1/4 = 3/4$

prob that after the second mutation, both of the triplets in the sequence code for arginine:
Current sequence is: CGGCAGT
Only the deletion of A to form CGGCGT would work
1/7 chance of this deletion happening

1/4 (chance of initial codon) $\times \frac{1}{7} = \frac{1}{28}$ Answer is E

73. $x^3 + px^2 + qx + p^2$

$2^3 + p(2^2) + q(2) + p^2 = 0$ $\quad 1^3 + p(1)^2 + q(1) + p^2 = -3.5$

$(\alpha)\ 8 + 4p + 2q + p^2 = 0$ $\quad 1 + p + q + p^2 = -3.5$

$(\beta)\ 2 + 2p + 2q + 2p^2 = -7$

$(\alpha) - (\beta)$: $\quad 6 + 2p - p^2 = 7$

$p^2 - 2p + 1 = 0$

$(p-1)^2 = 0$

$\Rightarrow p = 1. \Rightarrow C.$

74. Third law states (in the context) if the parachutist exerts a force on the surrounding air or the parachute, the surrounding air of or parachute will exert an equal but opposite force on the parachutist.

Equation 1 is an application of Newtons second law.

Equation 2 is another application of Newtons second law.

Equation 3 is wrong because the air resistance forces are not neccesarily the same.

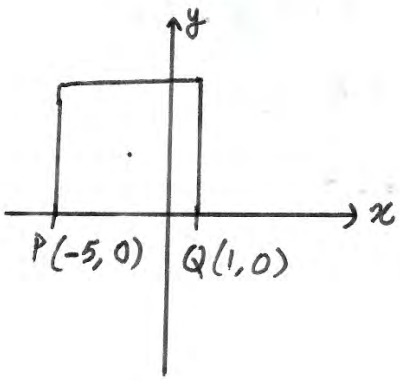
Equation 5 is an application of Newtons second law.

Equation 4 is an application of his third law because the force from the parachutist on the parachute causes the force from

the parachute on the parachutist. They are equal and opposite.

$\Rightarrow$ C.

75.



Length of the side of the square = 6.

Hence centre of circle is at:

$(-2, 3)$

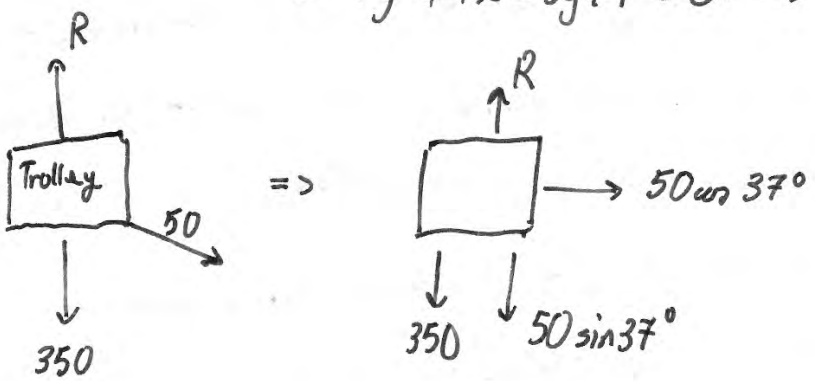
Has a radius of 3.

$\Rightarrow (x+2)^2 + (y-3)^2 = 3^2$

$\Rightarrow x^2 + 4x + 4 + y^2 - 6y + 9 = 9.$

$\Rightarrow x^2 + y^2 + 4x - 6y + 4 = 0. \Rightarrow$ C.

76.



Newtons Second law upwards on trolley:

$R - 350 - 50\sin 37^\circ = 0$

$R - 350 - 50(0.6) = 0$

$R = 350 + 30 = 380N$

Work done = Force × distance

$= 50 \cos 37^\circ \times 15$

$= 50 \times 0.80 \times 15$

$= 40 \times 15$

$= 600\ J \Rightarrow A.$

77. $a = 8.$

$ar^4 = 2$

$r^4 = \frac{2}{8} = \frac{1}{4}$

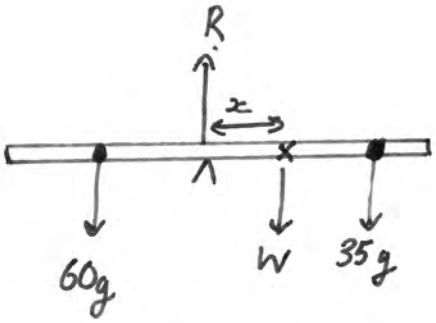
as $ar^5 > 0$, $r = +\sqrt[4]{\frac{1}{4}} = \frac{1}{\sqrt{2}}.$

Hence, $S_\infty = \frac{a}{1-r} = \frac{8}{1-\frac{1}{\sqrt{2}}} = \frac{8\sqrt{2}}{\sqrt{2}-1} = \frac{8\sqrt{2}(\sqrt{2}+1)}{(\sqrt{2}-1)(\sqrt{2}+1)}$

$= \frac{16+8\sqrt{2}}{2-1}$

$= 8(2+\sqrt{2}). \Rightarrow C.$

78.



Assume centre of mass is x metres to the right of the pivot.

Moments about pivot CW:

$35g(1.20) + Wx - 60g(0.8) = 0.$

$\Rightarrow Wx = 600(0.8) - 350(1.2) =$

$= 480 - 420 = 60.$

$\Rightarrow x = \frac{60}{W} = \frac{60}{150} = \frac{2}{5} = 0.40.$

Newtons Second law upwards on the plank:

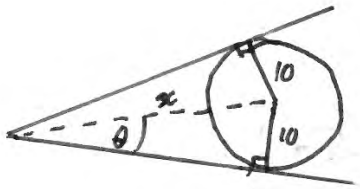
$R - W - 35g - 60g = 0$

$R = 150 + 350 + 600$

$= 1100N$

Answer is H.

79.



$\sin\theta = \frac{10}{x} = \frac{10}{20} = \frac{1}{2}$

$\theta = 30°$

Area of the triangles drawn in diagram above:

$2 \times \left(\frac{1}{2} \times x \cos\theta \times 10\right)$

$= x\frac{\sqrt{3}}{2} \times 10$

$= 5x\sqrt{3}$

$= 100\sqrt{3}.$

Area of circular Sector within triangles $= \frac{120}{360} \times \pi \times 10^2$

$= \frac{100}{3}\pi.$

Hence Shaded area $= 100\sqrt{3} - \frac{100}{3}\pi$

$= \frac{100}{3}(3\sqrt{3} - \pi)$.

80. Work energy principle:

ΔKE = WD by all forces

$\frac{1}{2}m(9^2 - 5^2) = mg\Delta h - Fd$ ← this is the work done by resistive forces = energy transferred in overcoming these forces.

$\frac{1}{2} \cdot 200(81 - 25) = 200 \times 10 \times (8 - 2) - Fd$

$100(56) = 2000(6) - Fd$.

$Fd = 12000 - 5600$

$= 6400\ J \Rightarrow B$.

81.

$7\cos\theta - 3\tan\theta\sin\theta = 1$

$7 - \frac{3\sin^2\theta}{\cos^2\theta} = \frac{1}{\cos\theta}$

$7 - 3\tan^2\theta = \sec\theta$

$7 - 3(\sec^2\theta - 1) = \sec\theta$

$7 - 3\sec^2\theta + 3 = \sec\theta$

$3\sec^2\theta + \sec\theta - 10 = 0$

$(3\sec\theta - 5)(\sec\theta + 2) = 0$

$\sec\theta = +\frac{5}{3}$ or -2 $\Rightarrow \cos\theta = +\frac{3}{5}$ or $-\frac{1}{2} \Rightarrow D$.

82. 1 is not correct because the cube must remain in horizontal equilibrium and without a frictional force, the only horizontal force is P and equilibrium would not be achieved.

2 is correct to achieve the equilibrium mentioned above. If you do the vector sum of P and the frictional force acting to the left, they will need to come to zero. This is only possible when that force acts to the left (or has a component to the left).

3. Not correct for reasons mentioned above.

4. A moment is calculated by force × perpendicula distance or perpendiculow force times distance. Either way, P × d is not one of these (about the edge in contact) hence this is not correct.

=> B.

83. $3x^2 = (a+2)x - 3$

$3x^2 - (a+2)x + 3 = 0.$

For two distinct real roots $b^2 - 4ac > 0$:

$(a+2)^2 - 4(3)(3) > 0$

$(a+2)^2 > 36$

$a+2 > 6$ or $a+2 < -6$

$a > 4$ or $a < -8$ => G.

84. Using $v^2 = u^2 + 2as$,

$2^2 = 8^2 - 2(10)s$

$4 = 64 - 20s$

$20s = 60$

$s = 3m.$

$s = ut + \frac{1}{2}at^2$

$3.0 = 8t - 5t^2$

$-5t^2 + 8t - 3 = 0 \Rightarrow 5t^2 - 8t + 3 = 0$

$(5t - 3)(t - 1) = 0.$

$t = 0.60s$ or $1s.$

We want the later time because the object has passed through $s = 3.0m$ once and is on its way down now.

$\Rightarrow t = 1.0s. \Rightarrow G.$

85.

$0 = mx_1 + 3.$ $0 = px_2 + 2$ We know $mp = -1$ as lines are perpendicular.

$\frac{-3}{m} = x_1.$ $\frac{-2}{p} = x_2.$

$x_2 - x_1 = 5$

$\frac{-2}{p} + \frac{3}{m} = 5$

$$\Rightarrow \frac{-2}{\left(\frac{-1}{m}\right)} + \frac{3}{m} = 5$$

$$2m + \frac{3}{m} = 5$$

$$2m^2 + 3 - 5m = 0$$

$$(2m - 3)(m - 1) = 0$$

$m = 1$ or $3/2$.

$m = 3/2$ as $m > 1$

$$\Rightarrow p = -\frac{2}{3}.$$

$$\Rightarrow m + p = \frac{3}{2} - \frac{2}{3} = \frac{5}{6} \Rightarrow D.$$

86.

1) (4.0) → 10 (2.0) → 0

PCLM →: $4 \times 10 + 2 \times 0 = 4 \times v + 2 \times 10$

$40 = 4v + 20$

$4v = 20$

$\Rightarrow v = 5$ m/s.

2) (4.0) → v (2.0) → 10

E_k before $= \frac{1}{2} \times 4 \times 10^2 = 200$ J.

E_k after $= \frac{1}{2} \times 4 \times 5^2 + \frac{1}{2} \times 2 \times 10^2 = 50 + 100 = 150$ J.

$\Rightarrow$ 50J lost.

$\Rightarrow E.$

87. $f(x) = x^3 - a^2x$

$\frac{df}{dx} = 3x^2 - a^2$.

To be increasing, $\frac{df}{dx} \geq 0$

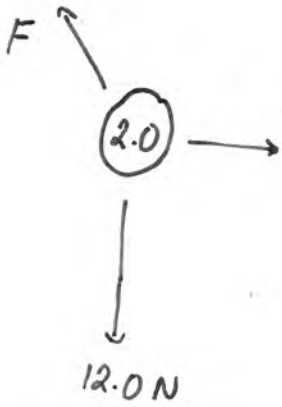
$3x^2 - a^2 \geq 0$

$a^2 \leq 3x^2$

$x^2 \geq \frac{a^2}{3}$.

$x \geq \frac{a}{\sqrt{3}}$ or $x \leq -\frac{a}{\sqrt{3}}$. => G.

88.



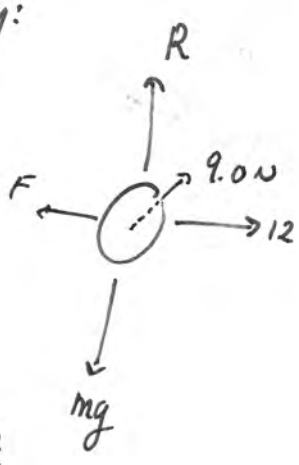
resultant force of the two applied forces $= \sqrt{9^2 + 12^2}\,N$

$= \sqrt{81 + 144}\,N$

$= \sqrt{225}\,N$

$= 15N$

Hence acceleration is given by:



$15 - \mu R = ma$

$15 - 0.25mg = ma$

$15 - 0.25 \times 20 = ma$

$ma = 10 \Rightarrow a = 5.0\,ms^{-2}$

89. Translation by vector $\begin{pmatrix} 4 \\ 3 \end{pmatrix}$: $y = (x-4)^2 + 3$.

Reflection in line $y = -1$: This is equivalent to a translation by $2(y+1)$ units downwards for each point on the curve.

$$2(y+1)$$
$$= 2\left((x-4)^2 + 3 + 1\right)$$
$$= 2(x-4)^2 + 8.$$

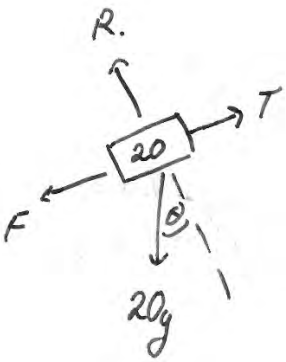
$\Rightarrow$ new curve: $y = (x-4)^2 + 3 - \left(2(x-4)^2 + 8\right)$

$$= -5 - (x-4)^2. \Rightarrow E.$$

90.

Newtons second law on 30kg mass: ↓

$$30g - T = 30 \times 2.5$$
$$300 - T = 75$$
$$\Rightarrow T = 225N.$$



Newtons 2nd law on 20kg mass →:

$$T - 20g\sin\theta - F = 20 \times 2.5$$
$$225 - 200\sin 30° - F = 50$$
$$225 - 100 - 50 = F$$
$$\Rightarrow F = 75N. \Rightarrow C.$$