ANSWERS TO GENERAL PAPER 2006

1. **NB:** ***It is possible to estimate the pH without a calculator***

pH (the negative logarithm of hydrogen ion concentration) is a range of values from 1 – 14 which correspond to $10^{-1} - 10^{-14}$. For example, if $[H^+] = 1 \times 10^{-5}$, it implies that pH = 5.

i.e. $\mathbf{[H^+] = a \times 10^{-n}}$.....................(i)

if a = 1, then pH = n.

However, when 'a' is not exactly 1.00, then n is not the pH of the solution. When 'a' is a value greater than 1.00 but less than 10.00, then the pH value is between n - 1 and n. For instance if the hydrogen ion concentration of a certain solution $[H^+] = 2.45 \times 10^{-8}$, because a = 2.45 which is not exactly 1.00 (i.e greater than 1.00 but less than 10.00), the actual pH is between n - 1 (i.e. 8 - 1 or 7) and n (i.e. 8), so the pH value is between 7 and 8 or = 7.x.

In this case however, pH = 3.80 is given. Because pH is not a whole number, then the 'a' part of $[H^+] = a \times 10^{-n}$ equation is not a whole number either, but greater than 1.00 and less than 10.00. **Recall** (When 'a' is not exactly 1.0, pH is between n - 1 and n).

In this question, since pH = 3.80, then it is between n - 1 and n, i.e. 4 - 1 (or 3) and 4. Thus we have found the value of n in

$[H^+] = a \times 10^{-n}$

$[H^+] = a \times 10^{-4}$

Since pH is not a whole number, then 'a' is not exactly 1.00 (but between1.00 – 10.00)

How do we find the '**a**' part?

NB: When $[H^+] = a \times 10^{-n}$.

$\mathbf{pH = n - \log^a}$ ....(ii)

log a = n - pH (n is usually greater than pH or equal to pH)

log a = 4 - 3.80

$\log a = 0.20$

$a = \log^{-1} 0.20$ (i.e. take the antilog of 0.20)

The antilog of 0.20 may be easily found using the four-figure tables.

$a = 1.58.$

Substituting **all the values** into the general formula (i) above, $[H^+] = a \times 10^{-n}$, we get $[H^+] = 1.58 \times 10^{-4}$

D

Endeavour to remember the equations (i) and (ii) above, because they are indispensible for solving problems involving pH and hydrogen ion concentration, $[H^+]$

2. **B**

3. From Faraday's First Law of Electrolysis:

$$m = zQ = zIt \;\ldots\ldots\ldots\ldots\ldots(1)$$

$$m = \frac{RAM \times I \times t}{q \times F} \;\ldots\ldots\ldots\ldots(2)$$

Where: m = mass of substance deposited
z = electrochemical equivalent constant
Q = quantity of electricity
I = current (in amperes)
t = time in seconds
RAM = Relative atomic mass
q = charge
F = Faraday's constant = 1 mole of electrons or 96500C

[Al, RAM = 27; charge, q = 3, t = 1.50hrs = 5400s]

From equation (2) above

$$I = \frac{m \times q \times F}{RAM \times t} = \frac{18.0 \times 3 \times 96500}{27 \times 5400} = 35.74 \text{ amperes or } 35.74\text{A}$$

A

4. The compound (Cl_2O_2) is called Dichlorine dioxide (IUPAC), represented as Cl-O-OCl. It is also called Chlorine (I) oxide.
Both elements in the compound have high electronegativity. In these types of compounds, the element with the **stronger electronegativity** is assigned a negative oxidation number (O.N), while the other with a relatively **lesser electronegativity** is assigned a positive O.N.
Thus, O which is relatively more electronegative is assigned a negative O.N, while Cl is assigned a positive O.N.
(NB: The most electronegative elements are F, O, N, Cl, in that order, with F being the most elecronegative).
Since it has the formula of a peroxide, O has an O.N. of -1 (instead of the usual -2), thus, for the neutral molecule, Cl_2O_2

$$Cl_2O_2 = 0$$
$$2(Cl) + 2(O) = 0$$
$$2Cl + 2(-1) = 0$$
$$2Cl - 2 = 0$$
$$2Cl = +2$$
$$Cl = +2/2 = +1$$

D

5. **B:** There is sharing of the electrons that make up the covalent bond in hydrogen gas.

6. **B:** 1, 2 and 3 only
A **catalyst** always remains chemically unchanged at the end of a chemical reaction although its physical properties may be altered. Negative catalysts slow down the rate of chemical reactions.

7. Usually, Hydrogen **ions** in solution act as reducing agents. Reducing agents change the colour of $K_2Cr_2O_7$ from orange to green.
However in the equation given:

$$\underset{\text{Orange}}{Cr_2O_7^{2-}} + H_2O \rightleftharpoons \underset{\text{yellow}}{CrO_4^{2-}} + 2H^+$$

We see that adding dilute H_2SO_4 produces more hydrogen ions (H^+) which shifts the equilibrium of the system to the left (the backward reaction is favoured) producing more of the orange coloured dichromate (VI) ions, $Cr_2O_7^{2-}$

A

8. H_2S is a gas (at room temperature) with a rotten egg smell. It is poisonous. It is moderately soluble in water in which it forms a dibasic acid. It is a strong reducing agent. It is a covalent compound. (NB: SO_2 is another reducing agent; however in the presence of the very strong reducing agents like H_2S, it behaves like an oxidizing agent and it is converted to atomic sulphur (yellow in colour) i.e. SO_2 is both a reducing agent and an oxidizing agent, unlike H_2S!)

A

9. Hydrolysis of sucrose (common sugar) yields equimolar amounts of glucose and fructose. Hydrolysis (splitting of a molecule by means of water) is the basic mechanism for digestion of food.
Industrial hydrolysis of sucrose is termed ***"inversion of sugar"*** and the enzyme involved is invertase.

NB: Maltose → glucose + glucose
Lactose → glucose + galactose
Sucrose → glucose + fructose

Maltose, lactose and sucrose are disaccharides, while glucose, fructose and lactose are monosaccharides. In each case, hydrolysis of the disaccharides produces equimolar amounts of the monosaccharides.

10.

$$c = \frac{1000m}{VM_0} \text{.................(i)}$$

[c = concentration, m = mass, V = volume in cm^3 or ml, M_0 = molar mass)
m = 0.28g, V = $100cm^3$, c = ?, $M_0 = 56$

$$c = \frac{1000 \times 0.28}{100 \times 56} = 0.05 \text{ moldm}^{-3}$$

C

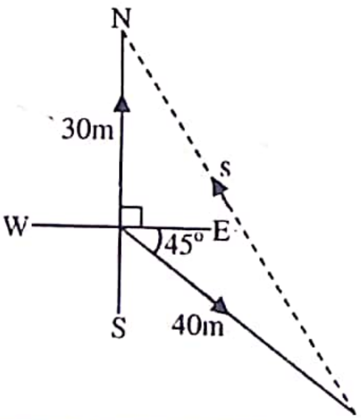
11. The 2 points P and Q are both 3 dimensional vectors whose co-ordinates are given in the brackets. Their distance apart can be given also in co-ordinates as follows:-

$$\vec{P} - \vec{Q} = (8 - 2, 5 - 1, 3 - (-2)$$
$$= (6, 4, 5)$$

The magnitude of this vector is then calculated as follows:

$$/P - Q/ = \sqrt{6^2 + 4^2 + 5^2} = 8.77$$

12. **D**



Their speeds of the individuals were given. With this, we can calculate the distances they've covered in 10 seconds using

$s = v\,t$ and $s = v\,t$

$= 4 \times 10 = 40m$ $= 3 \times 10 = 30m$

Their distance apart is given by the broken line, 's'. We employ the Cosine Rule

$s^2 = 30^2 + 40^2 - 2 \times 30 \times 40 \text{ Cos } (90 + 45^o)$

$s^2 = 900 + 1600 - 2400 \text{ Cos } 135$

$s^2 = 2500 - (-1697)$

$s^2 = 2500 + 1697 = 4197$

$s = \sqrt{4197}$

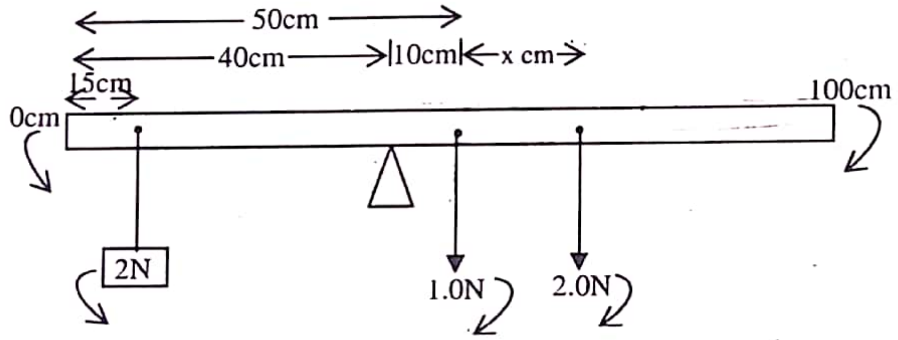
$= 64.7$ m

C

13. NB: The centre of gravity of a body is defined as the point through which its resultant weight acts. The following are facts:
- Centre of gravity of a uniform metre rule is at the 50cm mark
- Centre of gravity of a circular object is at the centre of the circle, same for a sphere, and cylinder
- Centre of gravity of a rectangle or square or parallelogram is at the **point intersection of the diagonals.**

C

14. A uniform metre rule is graded from 1 - 100cm mark. Also, the weight or mass of a uniform metre rule is placed at the centre (50m mark).
Now, from the question, the metre rule is said to have a weight of 1.0N, shown in the diagram below



It was pivoted at the 40cm, i.e. the knife edge is placed at 40cm. Weight of rule is 1.0N, thus this acts downwards at the 50cm mark, which is the centre of gravity of a uniform metre (100cm) rule. 2N is at the 15cm mark. To balance the rule with 2N, we must recall that anti-clockwise moments = clockwise moments.

Applying the **Principle of Moments:**

Sum of the moment in anti-clockwise direction = Sum of the moments in clockwise direction

$2 \times (40 - 15) = 1 \times 10 + 2\,(10 + x)$

$50 = 10 + 2\,(10 + x)$

$2(10 + x) = 40$

$10 + x = 20$

$x = 20 - 10 = 10cm$

Note that x is between 2N and the centre gravity. Taking the count from the zero mark, it becomes:

$50cm + 10cm = 60cm$ **A**

15. Number of mages, $n = \frac{360}{\theta} - 1$

$= \frac{360}{60} - 1$

$= 6 - 1 = 5$ images

C

16. **D**

17. **C**

18. The holes in the siren disc amplify the frequency of the sound wave.
Frequency of the note produced = no of holes × no of revolutions per second.
f = 132 rev/min = 132/60 = 2.2 revolutions/second.
Thus:

$$f = 200 \times 2.2 = 440Hz.$$

C

19. Note these facts about **mirrors**.

Concave mirror:

- Otherwise called **converging mirror**
- Forms both **real** and **virtual** images
- Real images are **inverted** and it is positive
- Virtual images are **erect** or upright and it is negative
- Focal length is **positive**

Convex mirror:

- Otherwise called **diverging mirror**
- Image formed is **virtual**
- Focal length is **negative**

(i). The type of mirror given determines whether the focal length will be negative or positive!
(ii). A positive image or a negative image does not necessarily depend on the type of minor but **only** on the description of the image itself. For instance, Real or inverted image = positive; virtual image = negative.
(iii). However, standard image of a convex mirror is always negative.

The same facts for image apply to the object.
Solving:
f = 20cm, v = $\frac{1}{2}$ of u = $\frac{u}{2}$, u = ? [v = image distance, u = object distance, f = focal length]

Using mirror formula: $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$,

$$\frac{1}{20} = \frac{1}{u/2} + \frac{1}{u}$$

$$\frac{1}{20} = \frac{2}{u} + \frac{1}{u}$$

$$\frac{1}{20} = \frac{2+1}{u} = \frac{3}{u}$$

$$\therefore u = 3 \times 20 = 60cm$$

B

Note the following:

- At centre of curvature, the object size = image size. (m = 1).
- At focal pivot, image varnishes to infinity. (m = ∞).
- At ½ distance between C and f, the magnification is halved. (m = 1/2).

20. Real depth, R.d. = 12m
Apparent depth, A.d. = ?

Refractive index, $\eta_w = \frac{R.d.}{A.d.}$

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

$$\frac{4}{3} = \frac{12}{A.d.}$$

$$\text{A.d.} = \frac{12\times 3}{4} = 9cm$$

21. **D:** The Focal Length of the eye changes in size and this is controlled by the ciliary muscle.

22. The e.m.f. is proportional to the length of a potentiometer that balances it.

$E \alpha L$

$E = KL$

$$K = \frac{E}{L}$$

Incomplete question! Solving this problem will require finding the value of K above; parameters missing.

23. **A**

24. $$Efficiency = \frac{Power\ output}{Power\ input} \times 100\% \ldots\ldots\ldots\ldots\ldots(a)$$

From the formula, power output is not known, likewise the power input. However, recall that:

Power, **P = IV**..............(b)

Also, note that <u>output</u> is to **secondary** while <u>input</u> is to **primary**. Solving using the parameters given:
$N_P = 400$ $N_S = 200$ $I_P = 3A$, $V_P = 240$ $V_S = ?$ $I_S = 5A$

NB: To get power output, you must find the voltage in the secondary coil "V_S". And, base on the parameters provided "V_S" can be found from the following relationship: $\frac{V_P}{V_S} = \frac{N_P}{N_S}$

$$\therefore \quad V_S = \frac{N_S V_P}{N_P} = \frac{200\times 240}{400} = 120V$$

Power Output = IV = $I_S \times V_S = 5 \times 120 = 600W$

Power Input = IV = $I_P \times V_P = 3 \times 240 = 720W$

From (a) above: $E = \frac{600}{720} \times 100\% = 83.3\%$

C

25. **A**

P-n junction means **positive** and **negative** junction of a semi-conductor. It is **forwa d biased** when the positive terminal of the e.m.f (battery) is connected to the positive semi-condu r and, the negative terminal to the negative semi-conductor such that there is free flow/exchange of ch. ge carniers (electrons (–) and Holes (+)) thus creating a good conduction of current. Here, current is increas d. (i.e. large current is obtained).

However, the reversal occurs in a **reversed-biased** p-n junction where there is obstruction to flow or incomplete flow/exchange of electrons and holes. Thus, producing small amount of current.
NB: p-n junction acts as a **Rectifier**.

26. **B**

27. **A:** Blue-green algae is otherwise called ***cyanobacteria***. They are holophytic bacteria in which the chlorophy ll is dispersed throughout the cytoplasm. (NB: the ***'blue-green algae'*** is not an algae, but a bacteria and it belongs to the Kingdom **Monera.**

28. **D:** Alexander Fleming discovered the *penicillins* (antibiotic).

29. **A**

Dioscorea cayanensis	- yellow yam
Dioscorea rotundata	- white yam
Dioscorea alata	- water yam
Dioscorea dumetorum	- bitter yam
Dioscorea bulbifera	- "air potato"
Dioscorea esculentum	- lesser yam

Of all the species of yam listed above, the white yam, yellow yam and water yam are the most commonly cultivated world-wide!

30. **A:** Xylem is composed of vessels of and tracheids, both of which are dead at maturity.

31. **D:** Excretion of urine is by the kidney

32. **B:** Alkaline pyrogallol (pyrogallic acid or 1,2,3-trihydroxybenzene) absorbs oxygen and it is thus used in experiments to illustrate that oxygen is given off during photosynthesis.

33. **C:** Invertase
Cane sugar is sucrose. In the body, it is broken down by sucrose, to glucose and fructose.
The three main classes of food are broken down by the following enzymes:

Carbohydrates	- amylases (e.g. ptyalin), saccharidases
Lipids	- Lipases
Protein	- Proteases e.g. pepsin, trypsin, chymotrypsin.

34. The femur is the single **largest** and **longest** bone in the body. The humerus is the second longest. The skull is a fusion of several bones (i.e, it is not a single bone).

35. **A:** Auxins are plant "growth hormones" produced at the apex of the shoots and roots. Auxins promote primary growth (while inhibiting the growth of side branches from axillary buds in stems). They also inhibit abscission (i.e. falling off of leaves and fruits from plants).
The most common naturally occurring auxin is indoleacetic acid (IAA). Other plant hormones and their functions include

(i) **Gibberellins:** They cause growth in stems and promote cell elongation and division. They are expressed in root and stem apices (just like auxins). They induce germination in dormant seeds, growth of axillary buds (unlike auxins) and increase fruit size.

(ii) **Ethylene (ethene):** It is expressed in leaves, stems and young fruits. Ethylene hastens the ripening of fruits, and retards lateral bud formation (just like auxins).

(iii) **Cytokinins:** They are produced in roots and stimulate growth (like auxins and gibberellins). Unlike auxins, they stimulate growth of lateral buds. Cytokinins delay ageing.

(iv) **Abscisic acid:** It is produced in mature green leaves, fruits and root caps. It is a growth inhibitor and opposes the effects of auxins, gibberellins and cytokinn. It causes the falling off of leaves and ripe fruits, induces dormancy, causes ageing in leaves and controls the opening and closing of stomata for water regulation

36. **C:** The hormone is adrenaline (epinephrine) and it prepares a person for **"flight or fight"**.

37. **A:** The most common cause of **thyroid gland swelling** is **goitre**. Goiter is often caused by nutritional deficiency of iodine. Such persons with goitre will benefit from diet fortified with iodine.

38. A

39. C: Abiotic factors are **"non-living factors"** e.g. Rainfall, wind, temperature, pressure, light, humidity, pH, soil, salinity etc. The boitic actors are the **"living factors"** and they include plants and animals.

40. C: **Mutualism is type of symbiosis** (symbiosis is any close and prolonged association of two or more organisms and it includes **parasitism, mutualism** and **commensalism**). Examples of mutualism is seen in lichens; mycorrhizas; nitrogen-fixing bacteria and root nodules; gut microorganisms and herbivores; cattle and tick birds, flowers and insect pollinators; etc.

41. C: Hydrophytes are plants that grow in fresh water e.g. water lily. Xerophytes grow in very dry conditions such as in deserts. Halophytes grow in salty water such as in seas.

42. B: Soil particles settle according to their densities with sand and gravel staying at the bottom while clay and humus settle at the top. In-between is coarse sand and silt. Capillary is estimated by the degree of rise of water up a tube that contains a soil sample when the bottom is brought in contact with water for a prolonged period of time. Air in soil is observed as bubbles when poured into the soil sample.

43. C: **Cholera** is contracted by ingestion of food or water contaminated with human faeces. The causative organism is ***Vibro cholera***.
Bilharziasis (also known as **schistosomiasis**) is contracted by wading in, bathing or drinking water contaminated with the cercariae (singular: cercaria) of the blood fluke of the **schistosoma species**.
Malaria is caused by the plasmodium parasite organisms (e.g. ***P. falciparium, P. ovale, P. vivax and P. malariae)*** and the vector is the female anopheles mosquito.
Sleeping sickness (otherwise called **trypanosomiasis**) is caused by the parasite ***Trypanosoma gambiense***. The vector is the tse-tse fly.
Thus, it is possible for the farmer to contract schistosomiasis, malaria and sleeping sickness without eating. Cholera is contracted only by eating or drinking.

44. C: Fluorides are protective on the teeth. Chlorine may be used to disinfect water.

45. B: Normal haemoglobin genotype is AA. Sickle cell haemoglobin genotype is SS, and such persons are sufferers of the disease. The carrier genotype is AS. Such a person possesses the trait but does not suffer from the disease. While a suffer manifests all the signs and symptoms of the disease, a carrier does not!

46. C:
Distillation takes advantage of the difference in boiling points of a mixture of liquids to separate them. Distillation is used to separate trichloromethane from grease as trichloromethane will have the lower boiling point and will form the distillate.
Chromatography employs the movement of a solvent over an **adsorbent** medium (e.g. paper or gel), for separation of a mixture of solutes. The solutes migrate at different speeds on the basis of their polarity.
Crystallization is used to separate solutes that are not stable to heat from solutions, especially when high purity is required. Crystallization is important in drug and sugar production.
Filtration separates an insoluble solid from a liquid medium.

47. **NB:** The properties of the element (e.g. ionization energy, electronegativity, electron affinity, atomic radius etc) exhibit periodicity i.e. ***the variation and reoccurrence of phenomena at regular intervals.***
Of the five properties mentioned above
(i) Ionization energy, electronegativity and electron affinity increase across a period but decrease down a group.
(ii) Atomic radius and ionic radius decrease across a period, but increase down a group (because of the extra electronic shell). Thus the correct order is:

Carbon < Boron < Beryllium < Lithium

A

NB: The elements listed here are in **Period 2.** Relative to period 2 elements, elements in the first period have smaller atomic radii, while those in the third period have larger atomic radii.

48. **D:** The noble gases (or rare gases) e.g. Argon, are chemically inert (i.e. they are unreactive). Thus, being unreactive, Argons keep the filament from burning too fast by creating an inert atmosphere and preventing oxygen from corroding the hot filament.

49. Solubility may be measured in grams of solutes per 100grams of solution (g/100g) or more commonly in moles per dm^3/Litre ($mol.dm^{-3}$). Note that the latter unit is the same as that of molarity.
This question is based on the latter unit from the question:

3.4g of $KNO_3 \rightarrow 250cm^3$ of water
xg of $KNO_3 \rightarrow 1000cm^3$ ($1dm^3$) of water

$$x = \frac{3.4 \times 1000}{250} = 13.6g \ of \ KNO_3$$

13.6 of KNO_3 is dissolved in $1dm^3$ of water [KNO_3, MW = 101g/mol]
solubility = number of moles in $1000cm^3$ ($1dm^3$)

$$n = \frac{mass}{Molar\ mass} = \frac{13.6}{101} = 0.135mol \approx 0.134mol.dm^{-3}$$

D

Alternatively, using the formula employed in Q.10 above:

$$c = \frac{1000m}{VM_0}$$

m = mass of solute in grams, V = volume of solvent in cm^3 or ml, M0 = Molecular weight of solute, c = molarity (concentration) or MOLAR SOLUBILITY...

We have that $c = \frac{1000 \times 3.4}{250 \times 101} = 0.134\,mol\,dm^{-3}$

This is much simpler approach!

50. $ZnCO_3 + H_2SO_4 \rightarrow ZnSO_4 + H_2CO_3$
[Zn = 65, C = 12, O = 16, H = 1, S = 32]
Since $ZnCO_3$ is in excess, the amount of $ZnSO_4$ produced depends solely on H_2SO_4 i.e. H_2SO_4 is the **limiting reactant** ($50.0cm^3$ of 4M (4 $mol.dm^{-3}$) sulphuric acid).
Since the stoichiometry shows a 1:1 relationship for H_2SO_4: Zn_2SO_4, then the number of moles of H_2SO_4 consumed equals the number of moles of $ZnSO_4$ produced.
For H_2SO_4.

Number of moles, $n = \frac{c \times V}{1000}$ (c = concentration, V = volume in cm^3 or ml)

$$n = \frac{4 \times 50}{1000} = 0.2 \text{ mol}$$

0.2 mol of H_2SO_4 was consumed in the reaction. From the 1:1 molar relationship, this implies that 0.2mol of $ZnSO_4$ was produced.
[$ZnSO_4$, MW = 161]

$$n = \frac{m}{M_0}$$ (m = mass, M_0 = molar mass)

$$0.2 = \frac{m}{161}$$

m = 0.2 × 161 = 32.2g.

A