PHYSICAL SCIENCES SOLUTIONS 2023

ANSWER EXPLANATIONS: CHEMISTRY 2023

1. B

Mass percent – is the total percentage of the mass of solute present in the solution.
In the reaction …

$CaCO_3(s) + 2\ HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + 2\ H_2O(l)$

The number of moles of pure $CaCO_3$ is half of the number of moles of HCl.

n (HCl) = c.V = 0,3 x $\frac{40}{1000}$ = 0,012 mol

n ($CaCO_3$) = ½ x 0,012 = 0,006 mol

Mass of pure $CaCO_3$ = n.M = 0,006 x 100 = 0,60 g

92% = $\frac{\text{mass of pure substance}}{\text{Total mass of substance}}$ x 100

Total mass of substance = 0,60/92 x 100 = 0,65 g
0,65 g of impure $CaCO_3$ is required to neutralize the HCl

2. C

NH_4^+ have covalent bonds between N and H.

Ionic bond for form between NH_4^+ cation and Cl^- anion.

3. C

Athletes feel tired and cramp up due to formation of lactic acid when insufficient oxygen reaches the muscles. It is the same acid that forms in sour milk.

4. A

A strong acid ionises completely in water while a weak acid ionises only partially. HCl is therefore a strong acid.
A concentrated acid is one in which many acid molecules are dissolved in a set volume of solution, while a dilute acid will have very few molecules per unit volume. A 0,1 mol.dm^3 has a low concentration and is diluted.

5. C

The change in energy, also referred to as the change in enthalpy (ΔH):

ΔH = energy of the products – energy of the reactants
= 60 – 20 = 40 kJ.mol^{-1}

The activation energy (E_a) is the minimum amount of extra energy required by reactants to get converted into product.

E_a = energy of the activated complex – energy of the reactants
= 100 – 20 = 80 $kJ.mol^{-1}$

6. C

Convert all to mass:

- n of Mg = 0,5 mol (divide number of particles with Avogadro's number)

m = n.M = 0,5 x 24 = 12 g

- m of carbon = 10 g
- n of N_2 gas = 0,5 mol (divide by molar volume of 22,4 dm^3)

m of N_2 gas = n.M = 0,5 x 28 = 14 g

- n of NaCl = c.V = 1 x 0,1 = 0,1 mol

m of Na Cl = n.M = 0,1 x (23 + 35,5) = 5,85 g

Nitrogen gas has the highest mass

7. B

Cations form when an atom loses one or more electrons. The resulting cation has the electron configuration of the noble gas atom in the row above it in the periodic table. The energy needed to remove an electron from a neutral atom is the ionization energy of that atom. Mg loses 2 electrons and forms a Mg^{2+} cation.

Anions are formed when a non-metal atom gains one or more electrons. The outer electron configuration of an anion is the same as that of a noble gas. The energy released when an electron is accepted by an atom in the gaseous state to form an anion is defined as the electron affinity of that atom. Each of the two Cl atoms will gain 1 of the electrons lost by Mg to form two Cl^- anions.

8. C

Hydrogen bonding is an intermolecular force and forms in liquid water as the hydrogen atoms of one water molecule are attracted towards the oxygen atom of a neighbouring water molecule. Due to these electrostatic attraction forces between hydrogen and oxygen, the molecules will position themselves as indicated in illustration III. The oxygen atom is partially negatively charged, and the hydrogen atom is partially positively charged.

9. C

A decomposition reaction can be defined as **a** chemical reaction in which one reactant breaks down into two or more products.
In the reaction $2H_2O \rightarrow 2H_2 + O_2$ water is broken down to hydrogen gas and oxygen gas. It is the same reactants used to form water.

10. C

A physical property is a characteristic of a substance that can be observed or measured without changing the identity of the substance. Physical properties include colour, density, hardness, and melting and boiling points.
Chemical properties describe the characteristic ability of a substance to react to form new substances; they include its flammability, acidity and susceptibility to corrosion.

11. A

The only liquid elements at standard temperature and pressure are Bromine (Br) and Mercury (Hg).

12. D

The process involves allowing seawater to flow into shallow flat beds through channels that are then sealed off. The sun heats the water until all of it evaporates, leaving mountains of salt behind. The salt is then collected and cleaned

13. C

A neutron (generally produced by some controlled process, not usually a natural event) collides with an atom of U-235. Momentarily, a U-236 atom forms, which then splits into two smaller atoms (Kr-93 and Ba-141) in the diagram. This process results in the release of three new neutrons, which can then initiate fission reactions with more atoms.

14. B

$pV = nRT$

$pV = \frac{m}{M}RT \quad (n = \frac{m}{M})$

$p = \frac{m}{VM}RT \qquad (d = \frac{m}{V})$

$p = \frac{d}{M}RT$

$d = \frac{pM}{RT}$

[p = 5(101,3) kPa, M = 2(16) g.mol^{-1}, R = 8,31 J.mol^{-1}.K^{-1}, T = 273 + 27 = 300 K]

density = $\frac{5(101,3)x32}{8,31x300}$ = 6,5 g.dm^{-3} (g/L)

15. D

An acid is a proton (H^+) donor. In the forward reaction water donates a proton and changes to hydroxide ions. In the reverse reaction carbonic acid donates a proton and changes to HCO_3^-.

16. A

The Joint Institute for Nuclear Research is an international intergovernmental organization established through the Convention signed on 26 March 1956 by eleven founding States and registered with the United Nations on 1 February 1957. JINR is situated in Dubna city in the Moscow Region of the Russian Federation.

17. B

Boyle's law states that the volume of a given mass of gas varies inversely with the pressure when the temperature is kept constant.
The gas molecules are moving and are a certain distance apart from one another. An increase in pressure pushes the molecules closer together, reducing the volume. If the pressure is decreased, the gases are free to move about in a larger volume. The pressure is manipulated (independent variable) and the effect thereof on the volume is measured (dependent variable). The amount of enclosed gas and the temperature are controlled variables and must be kept constant to ensure the investigation is a fair test.

18. B

The nitrogen atom in ammonia has three hydrogens attached, as well as a lone pair, in order to satisfy its octet. This gives ammonia a trigonal pyramidal geometry. Ammonia is a polar covalent molecule. (It is trigonal pyramidal and not symmetrical.) So, the type of intermolecular force is ion-dipole forces.

Carbon shares two pairs of electrons with each of the oxygen atoms to acquire a full outer shell of 8 electrons.CO_2 has a linear shape because the two regions of electron density repel each other to acquire maximum separation of 180 degrees.
Carbon dioxide is a non-polar molecule due to the symmetrical linear shape which cancels out the bond dipoles. Thus, the strongest intermolecular forces in it are the London-dispersion forces.

19. B

n(C) = 54,55/12 = 4,55 mol

n(H) = 9,09/1 = 9,09 mol

n(O) = 36,36/16 = 2,2725 mol

C : H : O
4,55 : 9,09 : 2,2725
2 : 4 : 1

Empirical formula = C_2H_4O

$Mr(C_2H_4O) = 44\ g.mol^{-1}$

$2 \times Mr(C_2H_4O) = 2 \times 44\ g.mol^{-1}$

= 88 $g.mol^{-1}$

Molecular formula = $C_4H_8O_2$

20. C

In beaker A (contains Zn, Cu^{2+}-ions and SO_4^{2-} -ions):

Zinc displaces copper from copper sulphate and generates zinc sulphate solution when added to $CuSO_4$ solution because zinc is a more reactive metal than copper.

$$Zn(s)+CuSO_4(aq)\rightarrow ZnSO_4(aq)+Cu(s)$$

When a strip of zinc metal is placed into a blue solution of copper (II) sulfate, a reaction immediately begins as the zinc strip begins to decay due to oxidation to zinc ions. At the same time, the copper (II) ions from the solution are reduced to copper metal, which causes the blue copper (II) sulfate solution to become lighter in colour.

In beaker B (contains Cu, Zn^{2+}-ions and SO_4^{2-} -ions):

No reaction will occur because zinc is a more reactive metal than copper.
Cu is not a strong enough reducing agent to reduce the Zn^{2+}-ions to Zn.

21. B

Mg loses 2 electrons to form Mg^{2+}-ions. Lost of electrons is oxidation.
Oxygen gains the 2 electrons from Mg and is reduced. The substance that is reduced is the oxidising agent.
When electrons are transferred, a positive cation and a negative anion is formed. These ions have an electrostatic attraction between them and form an ionic bond. (A covalent bond forms when electrons are shared).

22. A

Reversible reactions are ones which occur in both directions at the same time. If a reversible reaction is exothermic (gives out energy) in one direction it is endothermic (takes in energy) in the other direction. When a reversible reaction takes place in a closed system an equilibrium will be reached.

If the reaction is exothermic as written, an increase in temperature will favour the reverse reaction, decreasing the amounts of the products and increasing the amounts of reactants. Lowering the temperature will produce the opposite response.
If the reaction is endothermic as written, an increase in temperature will favour the forward reaction, increasing the amounts of the products and decreasing the amounts of reactants. Lowering the temperature will produce the opposite response.

Lowering the temperature with the ice caused the brown colour to disappear. The reverse reaction was favoured. The reverse reaction is therefore exothermic and the forward reaction is endothermic. The moles of N_2O_4 will increase.

23. B

Flask A: n of NaOH = c x V = 1 x 0,250 = 0,250 mol

Flask B: n of NaOH = c x V = 3 x 0,050 = 0,150 mol

Total n of NaOH = 0,400 mol
Total volume = 0,250 + 0,050 + 0,200 = 0,500 dm^3

Final concentration: $c = n/V = 0,400/0,500 = 0,8\ mol.dm^{-3}$

24. B

A pH of 5,8 is acidic (lower than 7)

Methyl orange is red in an acid and yellow in a base
Bromothymol blue is yellow in an acid and blue in a base
Phenolphthalein is colourless/transparent in an acid and pink in a base

25. B

The overall chemical reaction in a hydrogen fuel electrochemical cell involves the oxidation of hydrogen by oxygen to produce only water.

26. C

Hydrogen gas will react with oxygen gas to create an explosion when ignited by a spark. This led to the Hindenburg disaster in 1937 when the airship burst into flames and completely burned in 37 seconds. 13 Passengers and 22 crew lost their lives in the disaster. Helium is an inert gas, meaning it is unreactive and will not react with any substance.

27. C

The value of the mass number of hydrogen is 1, while the mass number of helium is 4. Considering the mass number, the helium is four times heavier than that of the hydrogen element. Helium consist of single atoms while hydrogen exist as a diatomic element in the form of hydrogen gas (H_2). Therefore, Helium gas is twice as heavy as hydrogen gas.

28. C

If the downward gravitational force is less than the upward buoyancy force then the object floats, otherwise it sinks. That is, if an object weighs less than the amount of water it displaces then it floats otherwise it sinks. A boat floats because it displaces water that weighs more than its own weight.

29. B

- A titration curve is a graphical representation of the pH of a solution during a titration.

- In a strong acid-strong base titration, the equivalence point is reached when the moles of acid and base are equal and the pH is 7.
- In a weak acid-strong base titration, the pH is greater than 7 at the equivalence point.
- In a strong acid-weak base titration, the pH is less than 7 at the equivalence point.

30. B

Electrode P is connected to the positive terminal of the battery and is the anode. In an electrolytic cell the anode is positive.

The negatively charged Cl^- ions will be attracted to the positive electrode P and will be oxidized to Cl_2 gas. Water is a stronger oxidising agent than Na^+ -ions and will be reduced at electrode Q to hydrogen gas (gas Y) and hydroxide ions.

The hydroxide ions forming as a product in this reaction will increase the pH to above 7.

31. B

Statement I is correct. Graph A has a steeper gradient. The gradient of the graph represents the rate of the reaction (volume of gas released per unit time).

Statement II is incorrect. The total volume of gas produced on completion of the reaction is the same for graphs A and B. This indicates that the mass of hydrogen peroxide used in both cases were the same.

Statement III is correct. An increase in temperature will increase the rate of the reaction. Graph A has a steeper gradient.

32. B

Volume = length x width x height

The volume of the cube is **2cm x 2cm x 2cm = 8cm^3.**

$$Density = \frac{Mass}{Volume}$$

$$Density = \frac{40g}{8cm^3} = 5.0\frac{g}{cm^3}$$

Therefore, **the cube is NOT gold**, but pyrite.

The value of pyrite is R 5.50 per gram.

The value of the cube is therefore **40 x R 5.50 = R 220.00**

33. C

The first periodic table which organizes all chemical elements by the number of protons in each atom and other properties was developed by Russian scientist Dmitry Mendeleev in 1869. On the 150th Anniversary of the inception of the periodic table, 2019 was celebrated as International Year of the Period Table of Chemical Elements by UNESCO.

34. B

Acetic acid is a by-product of fermentation, and gives vinegar its characteristic odour. Vinegar is about 4-6% acetic acid in water.

35. C

In the Haber process, the atmospheric nitrogen (N_2) is converted to ammonia (NH_3) by reacting it with hydrogen (H_2). Here a metal catalyst (platinum) is used and high temperatures and pressures are maintained. About 80% of the ammonia produced by industry is used in agriculture as fertilizer. Ammonia is also used as a refrigerant gas, for purification of water supplies, and in the manufacture of plastics, explosives, textiles, pesticides, dyes and other chemicals.

36. C

- Carbon exists everywhere - either in elemental form (on its own) or as a compound (in molecules with other elements). It's present in the pencils you write with, the paper you write on, the chalk, sugar, wood - you name it! In fact, about 12% of the atoms in the human body are Carbon atoms.
- Charcoal is compressed carbon. It is manufactured by burning wood with limited oxygen present.
- Graphite and diamonds are both allotropes of carbon.

In Graphite, each Carbon atom makes 3 single covalent bonds with 3 other Carbon atoms. The atoms form a flat layer of joined hexagonal rings. Each ring has 6 carbon atoms, and numerous such layers stacked on top of each other form the structure of Graphite.
In diamonds, each Carbon atom forms 4 single covalent bonds with 4 other Carbon atoms. The molecular structure in which the atoms are arranged in Diamond, and the presence of strong covalent bonds, make Diamond the hardest material in the world.

37. C

As an antacid, magnesium hydroxide suspension neutralizes gastric acid by reacting with hydrochloric acid in the stomach to form magnesium chloride and water. It is practically insoluble in water and does not have any effect until it reacts with the hydrochloric acid in the stomach.

38. D

Statement I is correct. Electron affinity increases upward for the groups and from left to right across periods of a periodic table because the electrons added to energy levels become closer to the nucleus, thus a stronger attraction between the nucleus and its electrons.
Statement II is correct. The atomic radius of atoms generally decreases from left to right across a period. There are some small exceptions, such as the oxygen radius being slightly greater than the nitrogen radius.
Statement III is correct.
The ionization energy decreases from top to bottom in groups and increases from left to right across a period. Thus, helium has the largest first ionization energy.

39. A

The y-axis indicates the amount of potential energy (in kJ/mol), and the x-axis represents the bond length (in picometers). The lowest point on the graph (position 3) represents the position of a stable bond and is used to determine bond energy and bond length.
Bond energy is the amount of energy that must be added to the system to break the bond that has formed.
Bond length is the distance between the nuclei of two adjacent atoms when they bond.

40. A

At sea level, water boils at 100 °C (212 °F). For every 152.4-metre increase in elevation, water's boiling point is lowered by approximately 0.5 °C.
Johannesburg is located on the Highveld plateau at an altitude of 1753 metres above sea level. The boiling point is lowered by approximately 6 °C.

41. D

Celsius, Fahrenheit and Kelvin are the three common temperature scales. Each of the scales has its uses, so it is likely that you will encounter them and would require you to convert between them.
A millimetre of mercury is a manometric unit of pressure, formerly defined as the extra pressure generated by a column of mercury one millimetre high.

42. C

Allotropes have different physical properties.

Carbon-12 and carbon-13 are stable and do not decay. The time it takes for ^{14}C to radioactively decay is described by its half-life. It has a half-life of

5 730 years. In other words, after 5 730 years, only half of the original amount of ^{14}C remains in a sample of organic material.

Allotropes of carbon have a different number of neutrons and therefore different mass numbers.

Allotropes have the same chemical properties due to the same chemical composition. They chemically react in the same way.

43. D

Nuclear power plants use a certain type of uranium (U-235) as fuel because its atoms are easily split apart. Although uranium is about 100 times more common than silver, U-235 is relatively rare at just over 0.7% of natural uranium.
Uranium is used to power military submarines.
The Hiroshima nuclear bomb was made from highly-enriched uranium-235.
Without uranium as a fuel source, nuclear power production wouldn't be possible, and the U.S. imports roughly 90% of the uranium it uses as fuel. Additionally, almost half of America's total uranium imports come from Russia and its allies Kazakhstan and Uzbekistan.

44. B

London (dispersion) forces are usually present in all molecules and are temporary. Cl_2 & CO_2 have London forces between their molecules.
Dipole-dipole forces are the attraction between the positive end of one polar molecule with the negative end of another polar molecule. HCl has dipole-dipole forces between its molecules.
Hydrogen bonds occur when there is either a fluoride, oxygen or nitrogen molecule which is bonded with hydrogen which is then joined with either a fluoride, oxygen or nitrogen molecule. H_2O & HF have hydrogen bonds between their molecules.
London forces are weaker than dipole-dipole and dipole-dipole are weaker than hydrogen bonds.

45. C

$$V = n.V_M = \frac{m.V_M}{M}$$

Volume of $O_2 = \frac{20(22,4)}{32} = 14\ dm^3$
Volume of $NH_3 = \frac{10(22,4)}{17} = 13,18\ dm^3$
Volume of $H_2 = \frac{20(22,4)}{2} = 124\ dm^3$
Volume of $SO_2 = \frac{15(22,4)}{64} = 5,25\ dm^3$
Hydrogen gas have the highest volume

46. D

Limestone is a sedimentary rock composed principally of calcium carbonate. It is commonly composed of tiny fossils, shell fragments and other fossilized debris.

47. A

Over 68 percent of fresh water is locked up in ice and glaciers. Another 30 percent of freshwater is in the ground. Fresh surface-water sources, such as rivers and lakes, only constitute about 1/150th of one percent of total water.

48. C

The Richter scale is used to measure an earthquake's magnitude (size). It was devised in 1935 by American seismologists Charles F. Richter. The earthquake's magnitude is determined using the logarithm of the amplitude (height) of the largest seismic wave calibrated to a scale by a seismograph.
The Newton scale measures force, the Beaufort scale measures wind speed and the Mohs scale measures hardness of minerals.

49. C

50. C

B represents the structure of a diamond. In a diamond, the carbon atoms are arranged tetrahedrally. Each carbon atom is attached to four other carbon atoms. It is a strong, rigid three-dimensional structure that results in an infinite network of atoms.

A represents the structure of Helium. It is an inert gas that consist of individual atoms.

D represents the structure of Lithium chloride. It is an ionic compound (a salt) in the form of crystals.

A represents the structure of Copper. Metals consist of a giant metallic structure. The atoms in a metal are arranged in a regular pattern and are closely packed together. Metallic bonding – the outer shell electrons become delocalised and surround the positive metal ions. There is a strong electrostatic force of attraction between them.

ANSWER EXPLANATIONS: PHYSICS

51. B

Before the collision:

$E_k = \frac{1}{2}mv_A^2 + \frac{1}{2}(2m)v_B^2$

$= \frac{1}{2}m(5)^2 + m(2{,}5)^2$

= 12,5 m + 6,25 m

= 18,75m

After the collision:

$E_k = \frac{1}{2}(3m)v_{AB}^2$

= 16,67m

E_k lost = 2,083m

% E_k lost = $\frac{2{,}083}{18{,}75} x\ 100$ = 11%

52. B

SI unit of: m = kg, v = $m.s^{-1}$

$p = m.v = kg.m.s^{-1}$

53. C

For an object moving with constant positive acceleration, the gradient of the vt-graph gives acceleration and will be a straight line with positive gradient.
Acceleration will be a horizontal line representing zero acceleration.
Displacement and distance graphs will not give a straight line. The gradient will increase as the speed increases.

54. B

All electromagnetic waves move at the same speed (3×10^8 $m.s^{-1}$)
UV-rays have a higher frequency, higher energy and shorter wavelength than microwaves.

55. C

The visible spectrum (white light) consist of the seven colours of the rainbow. Blue light has the highest frequency and red light the lowest.
Television stations use radio waves to broadcast their signals
Any red hot object emits infra-red light
X-rays can penetrate through human flesh, but not bones

56. B

R3 (10Ω): I = 0,6A

R1 & R2 (20Ω): I = ½ x 0,6 = 0,3A ($I \propto 1/R$)

Total I = 0,6 + 0,3 = 0,9A

57. D

$P = I^2.R$

For both resistors, R is the same

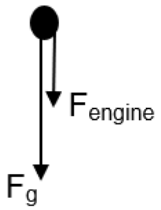
I for R3 is = 2 x I for R1

$P \propto I^2$

Therefore $2^2 = 4$ x bigger

58. B

$F_R = ma$



$F_g + F_{engine} = 8 \times 12$

$8 \times 9,8 + F_{engine} = 96$

F_{engine} = 96 – 78,4 = 17,6 N

59. C

In 10 minutes, the temperature increased by 26 °C.

In 15 minutes, the temperature increased by 26/10 x 15 = 39 °C.

The temperature of the block would therefore be 19 + 39 = 58 °C.

60. A

Distance travelled between dots (time intervals) decreases from M to Q, indicating a decrease in speed.
Distance travelled between dots (time intervals) is the same from Q to V, indicating constant speed.
Distance travelled between dots (time intervals) increases from V to Z, indicating an increase in speed.

61. B

Voltage over the battery = voltage over the parallel combination = 12V
Current divides equally between the identical bulbs is parallel. The total current is therefore 2 x 2 = 4A.

62. D

Energy needed = 385 x (1085 – 20,0) x 50/1000 = 20 501,25 J = 20,5 kJ

63. C

Difference in distance travelled **in one hour** = 41−28 = 14 km

Stoppage time is t = 14/42 = 0,333 h

= 0.333 × 60 minutes = 20 min in 1 hour

64. B

Distance covered by object A:
Δy = ½bh + lb
= ½(1)(10) + (10)(1)
= 15 m Upward

Distance covered by object B:
Δy = ½bh
= ½(1)(-10)
= -5 m = 5 m Downward

Distance between A and B = 15 + 5 = 20 m

65. C

The block is SLIDING up the slope, meaning that there is NO applied force in the direction of movement.

66. A

In the plane vertical to the inclined plane, Newton I apply. The forces are in equilibrium and the sum of all the forces = 0.

$F_N + F_A + F_{g\perp} = 0$

$F_N + F_A + mg.\cos 30° = 0$

67. D

All the forces in the free-body diagram acts on the block. N III forces acts on different objects.

68. B

$F_R = ma$

$F_x – F_f = 8a$

$80.\cos 30° - 40 = 8a$

$a = \frac{69{,}28 – 40}{8} = 3{,}66\ m.s^{-2}$

69. C

$f = \mu N$

$40 = \mu(58)$

$\mu = 0{,}69$

70. D

It is important to repeat measurements several times (at least 3, and preferably 5 times), because this shows how consistent or repeatable they are. Random errors will show up as random variations in the measured value, and the range of values will give an indication of the uncertainty.

71. D

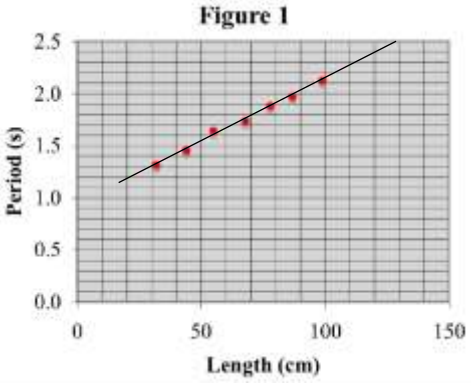
In this experiment the length was varied; length is the independent variable.
The influence of the varied length on the period was measured; the period is the dependent variable.
To ensure a fair test, there should only be one independent variable and all other variables that may have an influence on the dependent variable must be kept constant.
In this experiment mass and the angle of the pendulum is controlled variables.

72. B

From the graph, the period increases with increase of the length of the pendulum.

73. B

Draw a straight line of best fit through the points on the graph and extend (extrapolate) to a length of 130 cm. Read the value of the period from the y-axis. The value is 2,5 s.



74. D

F = qE … (q is a constant)

The force will be the strongest where the electric field strength is the strongest.
E is the strongest where the electric field lines are nearest to each other
F will be strongest at point B.

75. A

The direction of electric field lines is always away from a positive charge and towards a negative charge. All three charges are therefore positive.

76. D

- The direction of the electric field is always directed in the direction that a positive test charge would be pushed or pulled if placed in the space.
- For point S:
  - A positive test charge at point S will be pushed to the right by the +2 nC charge.
  - A positive test charge at point S will be pulled to the right by the -2 nC charge.
  - The direction of the resultant electric field at point S is therefore to the right.

- For point T:
  - A positive test charge at point T will be pushed to the right by the +2 nC charge.
  - A positive test charge at point T will be pulled to the left by the -2 nC charge.
  - $E = \frac{kQ}{r^2}$ … (Q has the same magnitude)
  - $E \propto \frac{1}{r^2}$
  - r for the -2 nC charge is smaller, therefore its electric field at point T will be stronger …(inverse proportionality).
  - The direction of the resultant electric field at point T is therefore to the left.

77. C

To solve this problem, award any value bigger than 1 to the charges. A and B have the same charge.

- Assume sphere A and B have charges of 10 nC each.
- When sphere C (neutral) touches A, electrons will be transferred until both have the same charge of +5 nC … (10 + 0)/2
- When sphere C (+5 nC) now touches B, electrons will be transferred until both have the same charge of +7,5 nC … (10 + 5)/2
- $F = k\frac{Q_A\,Q_B}{r^2}$ … (r is constant)
- $Q_A x\, Q_B$ initial = 10 x 10 = 100
- $Q_A x\, Q_B$ final = 5 x 7,5 = 37,5
- Ratio = 37,5/100 = 0,375 = 3/8

78. A

Newton III applies. The force exerted on A by B is equal to the force exerted by B on A, but in the opposite direction.

79. D

- $P = I^2R$ … (R is constant)
- $P \propto I^2$
- I will increase exponentially with increase in P.

80. B

- In both circuits P and Q, the reading on the voltmeter = the voltage over the battery ($V_{external}$).
- $R_{external}$ in circuit P is bigger than in circuit Q.
- I in circuit P is smaller than in circuit Q.
- V_{lost} in circuit P is smaller than in circuit Q.
- $V_P > V_Q$ and $A_P < A_Q$

81. B

When bulb B burns out:

- No current will flow through Y and Z.
- The reading on A_2 and A_3 will be zero.
- $R_{external}$ will increase and the reading on A will decrease.

82. B

- $P = V^2/R$ … (R is constant)
- $P \propto V^2$

- The voltage over each resistor in circuit 1 will be ½V.
- The voltage over each resistor in circuit 2 will be V.
- P in circuit 2 will be 4P

83. D
    - n_{Mg} = m/M = 12/24 = 0,5 mol
    - 2 x 0,5 = 1 mol of electrons is transferred … (Mg^{2+}-ion)
    - Charge transferred = 1 x (6,02 x 10^{23}) x (1,6 x 10^{-19}) = 9,63 x 10^{4} C

84. D

Q = IΔt

I = Q/Δt = rate of flow of charge

85. B

The following net force is possible:

- F_R = 1 N … (2 + 1 - 2)
- F_R = 3 N … (2 + 2 - 1)
- F_R = 5 N … (2 + 2 + 1)

86. C

The object's displacement after 20 seconds is: (Right as +)

- Equal to the area under the graph
- Δx = (10 x 6) + ½(6 x 6) – ½(4 x 6) = +70 m = 70 m to the right.

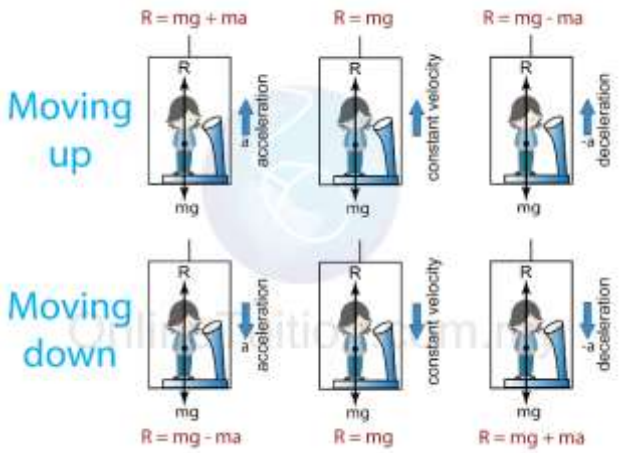
87. A

When light travels from air (less dense) into water (more dense), it slows down, causing it to change direction slightly towards the normal. This change of direction is called refraction.

88. A
    - When a positively charged object is brought close to the plate, electrons on the gold leave will be attracted to the plate.
    - The excess positive charge on the gold leave increase.
    - The gold leave diverges more.

89. C

- The reading on the scale = normal force. The normal force is equal to your apparent weight.
- Your free-body diagram has two forces, the force of gravity and the upward normal force from the elevator.
- normal force acting on you from the elevator:
  - N = mg if the elevator is at rest or moving at constant velocity
  - N = mg + ma if the elevator has an upward acceleration
  - N = mg - ma if the elevator has a downward acceleration
- The reading on the scale is largest when the lift moves upwards at an increasing speed.



90. A

Opposite charges attract and like charges repel.
Sphere Y is positively charged, and sphere Z is negatively charged.

91. C

A non-contact force is a force which acts on an object without coming physically in contact with it. Normal force is a contact force exerted by a surface in contact with an object.

92. D

- S will repel R downward, while T will repel R to the left.
- $F = k\frac{Q_A\,Q_B}{r^2}$ … (Q_A & Q_B is constant)
- $F \propto \frac{1}{r^2}$
- The force of S on R (downward) will be stronger.
- R will be repelled in the direction of P.

93. C

- As the stone moves towards the ground, it increases in speed.
- The gradient of a position-time graph represents speed.
- The gradient of the position-time graph must therefore increase as the stone moves towards the ground.

94. B

$v = \sqrt{\frac{GM}{r}}$ … [The mass of the earth (M) is a constant]

- $v \propto \frac{1}{r}$
- A satellite orbiting nearer to the earth will have a higher speed than a satellite orbiting further from the earth

95. B

A rheostat is a variable resistor which is used for controlling the flow of electric current either by increasing or decreasing the resistance. The following symbol is used for a rheostat in an electric circuit: 

96. A

The inverter will store DC power from the solar panel in your battery. During load shedding, the inverter will convert the DC power stored in your battery into AC power and feed the converted power into your home.

97. B

- The independent variable in this experiment is the material that the two resistors consist of.
- The dependent variable in this experiment is the resistance of the wires. The gradient of the graph represents the resistance (R = V/I).
- The current (I) can be manipulated with a rheostat, which will influence the reading on the voltmeter (ohm's law), to provide the data for the graph.
- Temperature, as well as the length and thickness of the wires will influence the resistance of the wires and must be kept constant.

98. B

- The resistance of the wires is determined by calculating the gradient of the graphs.
- For wire A:
  - Gradient = Δy/Δx
  - $R = \frac{\Delta y}{\Delta x} = \frac{V}{I} = \frac{6-0}{0{,}54-0} = 11{,}11\ \Omega$
- For wire B:
  - Gradient = Δy/Δx
  - $R = \frac{\Delta y}{\Delta x} = \frac{V}{I} = \frac{3{,}4-0}{0{,}6-0} = 5{,}67\ \Omega$

99. C

Michael Faraday's inventions include the Faraday cage, the dynamo, the electric motor, and the electric generator.

100. C

A prism transmits light but slows it down. When light passes from air to the glass of the prism, the change in speed causes the light to change direction and bend. Due to the differences in the refraction index between the air and the glass, light bends once entering the prism. Since the sides are angled, the light bends, even more, when it exits the prism. What makes this refraction so interesting is that different wavelengths of light refract differently. Longer wavelengths tend to refract less while shorter wavelengths tend to refract more, resulting in the separation of white light into the different colours of a rainbow.