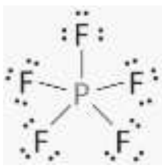
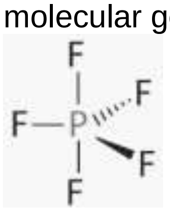
2022 SAASTA SCIENCE OLYMPIAD, GRADES 10-12 – MEMORANDUM

Question No.	Answer	Explanation
1	B	Eutrophication is the gradual increase in the concentration of **phosphorus, nitrogen, and other plant nutrients** in an aging aquatic ecosystem such as a lake.
2	B	The temperature of a substance is directly proportional to the average kinetic energy of the substance particles. Because the mass of these particles is constant, the particles must move faster as the temperature rises.
3	A	Sn is oxidized to Sn^{2+} at the anode. Sn is the reducing agent.
4	D	An electrolyte solution is a solution that generally contains ions, atoms or molecules that have lost or gained electrons, and is electrically conductive. Solutions of soluble ionic compounds (salts) will provide the ions required to conduct electricity.
5	D	Fractional distillation is the process by which oil refineries separate crude oil into different, more useful hydrocarbon products based on their relative molecular weights in a distillation tower. Fractions that are separated out include gasoline, diesel, kerosene, and bitumen. Teflon is a brand name for a synthetic chemical called polytetrafluoroethylene (PTFE)
6	D	HCl is a strong acid and ionizes completely in water to provide H^+-ions. The increase in $[H^+]$ will favour the forward reaction. The $[Cr_2O_7^{2}]$ increases, causing the colour to change to orange.
7	C	$n_{Cr} = \frac{m}{M} = \frac{0,26}{52} = 0,005$ mol $n_{gas} = 0.005$ mol (Ratio 1:1) $V_{gas} = n.V_m = 0,005 \times 22,4 = 0,112\ dm^3$
8	D	The amount of gas moles is the same for reactants and products. Increasing the pressure will therefore have no effect on the equilibrium. The amount of HBr will stay the same, but the effect of decrease in volume is an increase in concentration of all the gasses in the container.
9	A	The equivalence point of a neutralization reaction is when both the acid and the base in the reaction have been completely consumed and neither of them are in excess. When a strong acid neutralizes a weak base, the resulting

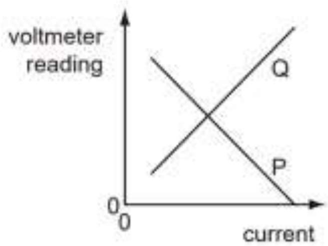
		solution's pH will be less than 7 due to the hydrolysis of the salt (ammonium chloride). The $[H_3O^+]$ will be higher than the $[OH^-]$. $NH_4^+ (aq) + H_2O (aq) \rightarrow NH_3(aq) + H_3O^+ (aq)$
10	C	Mole ratio is 2:1. The amount of HCl reacting is double the amount of CO_2 produced.
11	B	Number of molecules = n x Avogadro's number = $\frac{m}{M}$ x Avogadro's number
12	B	The change at t = 15 s had no influence on the equilibrium and could be due to a catalyst OR an increase of the surface area of substance A. The change at t = 25 s decreased both the rates of the forward and reverse reactions and had an influence on the equilibrium (favoured the forward reaction). A decrease in temperature is the only correct option here.
13	B	Compressed air or different combinations of oxygen, hydrogen, nitrogen and helium are used in scuba tanks. The bends occur when dissolved gases (mainly nitrogen absorbed through the skin before diving) come out of solution in bubbles and can affect just about any area of the body including joints, lung, heart, skin and brain.
14	C	$PbO_2(s)+HSO_4^-(aq)+3H^+ \rightarrow PbSO_4(s)+2H_2O(\ell)$ (reduction) $Pb(s)+HSO_4^-(aq) \rightarrow PbSO_4(s)+H^+(aq)$ (oxidation) E_{cell} = 1,69 – (-0,36)
15	D	Gases used in welding and cutting processes include: • shielding gases such as carbon dioxide, argon, helium, etc. • fuel gases such as acetylene, propane, butane, etc. • oxygen, used with fuel gases and also in small amounts in some shielding gas mixtures.
16	C	Galvanisation is a process of coating "Iron or Steel" with Zinc to protect it from the Rusting
17	C	Heavy water is water that contains heavy hydrogen - also known as deuterium (the hydrogen isotope with a mass double that of ordinary hydrogen) - in place of regular hydrogen. It has a unique atomic structure and properties coveted to produce nuclear power and weapons. Water in the dead sea has a high density due to the high salt content.
18	A	Liquefied petroleum gas (LPG), also called LP gas, any of several liquid mixtures of the volatile hydrocarbons propene, propane, butene, and butane.
19	D	The electrostatic attraction between an ion and a molecule with a dipole is called an ion-dipole attraction. These attractions play an important role in the dissolution of ionic compounds in water.
20	B	Copper nitrate - blue Magnesium sulphate – white (Mg salts are white and colourless in solution) Iron oxide – red/black

		Cobalt chloride – blue/pink
21	B	Phosphorous and Sulphur – solid Chlorine - gas
22	B	At equilibrium the concentration of reactants and products stays constant, but not equal. Each reactant and product may have different concentrations. If none of the reactants or products is in the gas phase, equilibrium can be obtained in an open container.
23	A	The metals used in the aircraft manufacturing industry include steel, aluminium, titanium and their alloys. The heavy weight and softness of lead makes it unsuitable for this purpose.
24	B	The simple definition of water hardness is the amount of dissolved calcium and magnesium in the water.
25	B	A lack of iodine can cause an abnormal enlargement of the thyroid gland and abnormal weight gain. As you proceed down a group, the ionic radius increases as additional energy levels are filled farther from the nucleus. Therefore fluorine, the top element, has the smallest ionic radius. In the halogen family, the most active nonmetal would be the top element, fluorine, because it has the highest electronegativity.
26	C	There are four main kinds of batteries used in electric cars: lithium-ion, nickel-metal hydride (NiMH), lead-acid, and ultracapacitors. Lithium-ion batteries are the current standard and offer a longer range and retain energy better.
27	D	Density of water is $1 g/cm^3$. ($d = m/v$) Ball D is the only ball with a density less than water ($d = 20/25 = 0{,}8 g/cm^3$).
28	C	When an acidic solution is diluted with water the concentration of H + ions decreases and the pH of the solution increases towards 7. To make the pH change by 1, a tenfold dilution is required (eg adding $9 cm^3$ of water to $1 cm^3$ acid). $15 \times 9 = 135 cm^3$
29	B	$2Mg + O_2 \longrightarrow 2MgO$ $n_{Mg} = m/M = 5/24 = 0{,}208$ mol $n_{Oxygen} = V/V_M = 2{,}24/22{,}4 = 0{,}1$ mol 0,1 mol O_2 will react with $0{,}1 \times 2 = 0{,}2$ mol Mg $Mg_{excess} = 0{,}208 – 0{,}2 = 0{,}008$ mol $m = n.M = 0{,}008 \times 24 = 0{,}192$ g Mg
30	D	A :- Boyle's Law (Temperature is constant) => Pressure is inversely proportional to Volume => graph is rectangular Hyperbola

		B :- Charles Law (Pressure is constant) => Volume is directly proportional to Temperature => Graph is a straight line passing through origin C :- Gay Lussac's Law (Volume is constant) => Pressure is directly proportional to Temperature => Graph is a straight line passing through origin
31	C	In A - Fe^{3+} is reduced to Fe. In B – C is oxidized to C^{4+}. In D – Zn is oxidized to Zn^{2+}. C represents an acid-base reaction where protons (H^+) are transferred from water to the carbonate ion. No change in oxidation numbers.
32	D	The central atom, P, has five valence electrons and each fluorine has seven valence electrons, so the Lewis structure of PF_5 is  All electron groups are bonding pairs, so PF_5 is designated as AX_5. This gives a total of five electron pairs. With no lone pair repulsions, we do not expect any bond angles to deviate from the ideal. The PF_5 molecule has five nuclei and no lone pairs of electrons, so its molecular geometry is trigonal bipyramidal. 
33	B	M = 2(27) + 3[32 + 4(16)] = 342 $g.mol^{-1}$ %Al = 2(27)/342 = 15,80%
34	A	The human body is approximately 99% comprised of just six elements: Oxygen, hydrogen, nitrogen, carbon, calcium, and phosphorus. Another five elements make up about 0.85% of the remaining mass: sulfur, potassium, sodium, chlorine, and magnesium. All these 11 elements are essential elements.
35	A	When salt is added, the freezing point is lowered, and the boiling point is raised. Salt molecules block water molecules from packing together when temperature is lowered. Sodium chloride dissociates into sodium and chlorine ions. Water is a dipole. The positively charged sodium ions align with the oxygen side of a water molecule, while the negatively charged chlorine ions align with the hydrogen side. The ion-dipole interaction is stronger than the hydrogen bonding between the water molecules, so more energy is needed to move water away from the ions and into the vapor phase.

36	B	The Chernobyl disaster was a nuclear accident that occurred on 26 April 1986 at the No. 4 reactor in the Chernobyl Nuclear Power Plant, near the city of Pripyat in the north of the Ukrainian SSR in the Soviet Union. It is one of only two nuclear energy accidents rated at seven—the maximum severity—on the International Nuclear Event Scale, the other being the 2011 Fukushima nuclear disaster in Japan.
37	D	Endothermic – energy is taken up. All electrolysis processes are redox reactions. Reduction: $2\ H^+\ (aq.) + 2\ e^- \rightarrow H_2\ (g)$ Oxidation: $2\ H_2O\ (l) \rightarrow O_2\ (g) + 4H^+\ (aq) + 4\ e^-$
38	B	Green hydrogen is a byproduct that is produced from water electrolysis using energy from renewable sources such as solar, wind, biofuel and hydropower. Green hydrogen is a more attractive form of energy than grey or brown hydrogen, which are produced by natural gas and coal, respectively.
39	D	All three, increase in temperature, concentration and pressure will increase the rate of the forward and reverse reactions.
40	A	**Investigation 1:** The conductivity of the same salt solution is determined at three different temperatures. Independent: temperature, Dependent: conductivity, Constant: salinity. **Investigation 2:** The conductivity of salt solutions with different salinity (salt concentration) is determined at the same temperature. Independent: salinity, Dependent: conductivity, Constant: temperature.
41	B	Conclusion (ii) is incorrect. The temperature of the sea water was not the dependent variable in any of the two investigations.
42	B	**Salinity of 32 (parts per thousand):** At 27 °C, conductivity is 47 (millisiemens/cm) At 23 °C, conductivity is 51 (millisiemens/cm) A temperature change of 4 °C changes conductivity with 4 (millisiemens/cm) (Any salinity value will give the same result)
43	A	A strong acid is any acid that ionizes completely in solutions. Dilute acids are acids that contain a large amount of water.
44	B	The Haber process converts atmospheric nitrogen (N_2) to ammonia (NH_3) by a reaction with hydrogen (H_2) using a metal catalyst under high temperatures and pressures.
45	B	While the particles of an ideal gas are assumed to occupy no volume and experience no interparticle attractions, the particles of a real gas do have finite volumes and do attract one another. As a result, real gases are often observed to deviate from ideal behavior. A real gas deviates most from an ideal gas at low temperatures and high pressures.

46	C	The empirical or simplest formula gives the smallest whole number ratio of elements in a compound, while the molecular formula gives the actual whole number ratio of elements. The molecular formula is a multiple of the empirical formula.
47	A	K and Br are elements in the same row of the Periodic table. K is a metal in group 1 and forms a K^+-ion with 18 electrons. Br is a non-metal in group VII (17) and forms a Br^- -ion with 18 electrons.
48	A	Air is a mixture of different gases. Air mostly contains nitrogen and oxygen in about 78% and 20% respectively. All the others are pure substances.
49	D	Most atoms are 0.1 to 0.2 nm wide, strands of DNA around 2 nm wide, red blood cells are around 7000 nm in diameter, while human hairs are typically 80,000 nm across.
50	D	Liquid nitrogen is the liquefied form of the element nitrogen that's produced commercially by the fractional distillation of liquid air. At normal pressure, liquid nitrogen boils at −195.8 °C. All the other substances are still in liquid form at room temperature.
51	B	10^{-26} kg
52	B	Alpha decay. Alpha decay represents the disintegration of a parent nucleus to a daughter through the emission of the nucleus of a helium atom. Alpha particles consist of two protons and two neutrons bound together into a particle identical to a helium nucleus. $^{227}_{89}Ac \longrightarrow ^{227}_{90}Th + ^{0}_{-1}\beta$..................beta decay $^{227}_{90}Ac \longrightarrow ^{223}_{88}Q + ^{4}_{2}\alpha$.....................alpha decay Beta-decay or β decay represents the disintegration of a parent nucleus to a daughter through the emission of the beta particle. Beta particles are high-energy, high-speed electrons or positrons emitted by certain types of radioactive nuclei. The beta particles have a greater range of penetration than alpha particles but still much less than gamma rays. The beta particles emitted are a form of ionizing radiation, also known as beta rays. The production of beta particles is termed beta decay.
53	C	Voltage is directly proportional to resistant (V=IR) and resistance increases with temperature due to increased vibrations of the molecules inside the conductor. Therefore, voltage increases as temperature increases. In a light dependent resistor, the light transfers energy to the electrons in a semiconductor material. This causes the electrons to be freed from their fixed positions in the crystal structure, enabling them to move freely in the material. Therefore, the higher the light level the material becomes a better conductor

		with a lower resistance. Therefore the voltage will decrease as the light level increases. Voltage is equal to current multiplied by resistance (V=IR). (2) Resistance is equal to voltage divided by current (R = V/I)
54	C	RPQ=(20Ω+8Ω)||(6Ω+8Ω)||(7Ω) ⟹RPQ=(28Ω)||(14Ω)+(7Ω) ⟹RPQ1=281+141+71 ⟹RPQ1=284+2+1 ⟹RPQ=4Ω
55	D	 The graph is that of the p.d. across the FIXED resistor against the current through it. This current is the same flowing in the whole circuit since it is a series connection. When the variable resistor has the zero value, the total resistance in the circuit is 2Ω. So there is 12V across the 2Ω resistor and the current is a maximum (12/2 = 6.0A). On the graph, the point is at coordinates (6 ; 12) When the variable resistor is at 10Ω (maximum), the total resistance in the circuit is 12Ω So the current is at minimum. (12/12 + 1A) and the voltmeter will read 2V. This is obtained from the potential divider equation. p.d. across the fixed resistor = [2/(10 + 2)] x 12 = 2V This corresponds to point with coordinates (1 ; 2) So the graph does not start at point (0 ; 0) and has a positive gradient since it passes through points (1 ; 0) and (6 ; 12)
56	D	Ratio = I_P / I_Q = R_Q / R_P = (4/9) / 8 = 1/18
57	A	$P_{(W)} = I^{2}_{(A)} \times R_{(\Omega)}$ = $(0.5)^2$ x 180 = 45W
58	A	Power supplied to heater = VI = I^2R = V^2 / R From the potential divider equation,

		p.d. across the heater = [6.5 + 1.5)] x 20 = 16.25V Power supplied to heater = VI = V^2 / R = $(16.25)^2$ / 6.5 = 40.625W
59	C	power = energy / time = (force × distance / time) = kg m^2 s^{-2} / s = kg m^2 s^{-3}
60	C	units of L^2: m^2 ρ: kgm^{-3} v^3: m^3 s^{-3} ($C = P / L^2 \rho v^3$) hence units of C: kg m^2 s^{-3} m^{-2} kg^{-1} m^3 m^{-3} s^3 or any correct calculation leading to C having no units
61	B	Power available from wind = 3.5 × 10^5 × 100 / 55 (= 6.36 × 10^5) v^3 = 3.5 × 10^5 × 100 / (55 × 0.931 × $(25)^2$ × 1.3) v = 9.4 m s^{-1} L = 25m, ρ of air = 1.30, C = 0.931 Efficiency = 55% Electric power output, P = 3.50 x 10^5W Wind speed = v 55% = 3.50 x 10^5W Power available from wind, 100% = 3.50 x 10^5 x 100/55 = 6.36 x 10^5W $P = CL^2\rho v^3$ So, $v^3 = P / CL^2\rho$ = 6.36 x 10^5 / (0.931 x $(25)^2$ x 1.3) v = 9.4 ms^{-1} The electrical power output of the turbine is less than the power available from the wind because not all kinetic energy of the wind is converted to kinetic energy of the blades / generator. The conversion to electrical energy is also not 100 % efficient since heat is produced in the generator.
62	D	- Not all kinetic energy of wind converted to kinetic energy of blades generator - Conversion to electrical energy not 100% efficient - heat produced in generator / bearings
63	B	The point where all the weight of the body is considered/seems to act.
64	B	Vertical component of T (= 30 cos40°) = 23N
65	A	The sum of the clockwise moments about a point equals the sum of the anticlockwise moments (about the same point).
66	C	(moments about A): 23 × 1.2 (27.58) = 8.5 × 0.60 + 1.2 × W W = 19 or answer of 18.73 (N)
67	D	For forces in equilibrium resultant force (and moment) = 0 Upward force does not equal downward force Horizontal component of T not balanced by forces shown

		The answer is all of the above because of the following: A very basic concept when dealing with forces is the idea of equilibrium or balance. In general, an object can be acted on by several forces at the same time. A force is a vector quantity which means that it has both a magnitude (size) and a direction associated with it. If the size and direction of the forces acting on an object are exactly balanced, then there is no net force acting on the object and the object is said to be in equilibrium. Because there is no net force acting on an object in equilibrium, then from Newton's first law of motion, an object at rest will stay at rest, and an object in motion will stay in motion.
68	B	$v = f * \lambda$ $\lambda = 40 / 50$ $= 0.8$ m
69	D	Incident and reflected waves interfere / superpose
70	A	1.5λ for PQ hence PQ = 0.8×1.5 $= 1.2$ m
71	D	Displacement is the distance the rope or particles are above or below from the equilibrium undisturbed position.
72	A	amplitude (= 80 / 4) = 20 mm During one oscillation, point A moves a distance of 80 mm, it will return to its original position. Any point would move a distance = 4 time the amplitude during one oscillation. Amplitude is the maximum displacement from the equilibrium position.
73	B	$v = f\lambda$ or $v = \lambda/T$ $f = 1/T = 1/0.2$ (5 Hz) $v = 5 \times 1.5 = 7.5$ m s^{-1}
74	A	Transverse as particles/rope movement is perpendicular to direction of travel
75	C	The amount of charge that flows per unit time is equal to the electric current
76	C	$P = V^2/R$ $= (240)^2/18$ $= 3200$W
77	B	$I = V/ R$ $= 240/18$ $= 13.3$A
78	A	Charge = It $= 13.3 \times 2.6 \times 10^6$ $= 3.47 \times 10^7$ C

79	B	Number of electrons = $3.47 \times 10^{7}/1.6 \times 10^{-19}$ $= 2.17 \times 10^{26}$ Number of electrons per second = $2.17 \times 10^{26}/2.6 \times 10^{6}$ $= 8.35 \times 10^{19}$
80	B	W = 206 and X = 82 Y = 4 and Z = 2 Alpha decay is observed for the elements heavier than lead and for a few nuclei as light as the lanthanide elements. It can be written symbolically as ${}^{A}_{Z}X \longrightarrow {}^{A-4}_{Z-2}X + {}^{4}_{2}He.$ We use X to indicate any element defined by its nuclear charge, Z and Z-2 in this equation.
81	C	Mass-energy is conserved Mass is therefore never conserved because a little of it turns into energy (or a little energy turns into mass) in every reaction. But mass - energy is always conserved. Energy cannot be created out of nothing. It can only be created by destroying the appropriate amount of mass according to $E = mc^{2}$.
82	A	Not affected by external conditions/factors/environment
83	C	Force: kg m s^{-2}
84	B	I^{2} : A^{2} l: m x: m $F = \frac{KI^{2}l}{x}$ Substitute the SI unit of measurement and make K subject of the formula kg m $s^{-2} = \frac{K.A^{2}m}{m}$ kg m s^{-2} = K. A^{2} K = kg m s^{-2} A^{-2}
85	D	elastic: total kinetic energy is conserved, inelastic: loss of kinetic energy
86	B	initial momentum: $4.2 \times 3.6 - 1.2 \times 1.5$ $= 15.12 - 1.8$ $= 13.3$ final momentum: $4.2 \times v + 1.5 \times 3$ $v = (13.3 - 4.5) / 4.2$ $= 2.1 ms^{-1}$
87	A	Initial kinetic energy = $\frac{1}{2} m_{A}(v_{A})^{2} + \frac{1}{2} m_{B}(v_{B})^{2}$ $= 27.21 + 1.08$ $= 28$

		final kinetic energy = 9.26 + 6.75 = 16
88	C	force per unit cross-sectional area
89	A	E = stress / strain $E = 0.17 \times 10^{12}$ stress = $0.17 \times 10^{12} \times 0.095 / 100$ = $1.6(2) \times 10^{8}$ Pa
90	A	Force = (stress × area) = $1.615 \times 10^{8} \times 0.18 \times 10^{-6}$ = 29N
91	D	p.d. = $\frac{\text{work done / energy transformed}}{\text{Charge}}$ (from electrical to other forms)
92	B	maximum 20V
93	A	minimum = (600 / 1000) × 20 = 12V
94	D	$R = \rho l / A$ $\rho = 18 \times 10^{-9}$ $R = (18 \times 10^{-9} \times 75) / 2.5 \times 10^{-6}$ $= 0.54\ \Omega$
95	B	V = IR R = 38 + (2 × 0.54) I = 240 / 39.08 = 6.1 (6.14) A
96	C	$P = I^2R$ or $P = VI$ and $V = IR$ or $P = V^2/R$ and $V = IR$ $P = (6.14)^2 \times 2 \times 0.54$ P = 41 (40.7) W
97	C	Area of wire is less (1/5) hence resistance greater (×5)
98	A	Displacement in the direction of the force
99	D	kinetic energy = $\frac{1}{2} mv^2$ kinetic energy = $\frac{1}{2}\ 0.4\ (2.5)^2$ = 1.25 or 1.3 J
100	B	v = u + at = 4.23 + 9.81 × 1.5 = 19.0 m s^{-1}