SOUTH AFRICAN AGENCY FOR SCIENCE AND TECHNOLOGY ADVANCEMENT
55th SCIENCE OLYMPIAD

GRADES 10 -12

2019

INSTRUCTIONS

Please read the instructions carefully before answering the questions

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This is a multiple choice paper. Please answer all the questions on the answer sheet provided. Each question is followed by answers marked A, B, C, and D. **Only one answer is correct**. Choose the correct answer and shade the corresponding circle on the answer sheet completely, using an HB pencil.

NB! The answer sheets are marked electronically – do not make any other dots or marks on the answer sheet. Select only one answer for each question or your answer will be discarded**. Ensure that you shade your selection clearly.**

Note that the question numbers 1 to 100 on the answer sheet moves from top to bottom in several columns. Ensure that the number of your selection on the answer sheet corresponds with the number of the question in your examination paper. Should you make a mistake, please erase the incorrect answer completely

The use of **non-programmable** electronic calculators is permitted.

To avoid disqualification - You are required to complete **all** the information requested on the answer sheet. Please complete the information in script, as well as shade the corresponding blocks. If the corresponding blocks are not shaded appropriately, your results will be returned without a name and you will be disqualified. Do not fold the answer sheets.

Three hours are allowed to answer the questions

1   The volume of a given object is 16 cm^3. What is its volume in m^3?

A 1.6×10^{-1} m^3
B 1.6×10^{-3} m^3
C 1.6×10^{-5} m^3
D 1.6×10^{-8} m^3

2   For many purposes it is convenient to compare substances with one another. Pure water at 4°C is often used as a standard substance and we define   the relative density as:

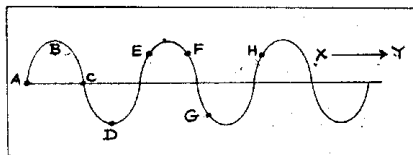$$\text{relative density} = \frac{\text{density of substance}}{\text{density of water at } 4^{\circ}C}.$$

The dimensions of relative density are:

A   Dimensionless
B $[M^2L^{-3}]$
C $[ML^{-3}]$
D $[ML^{-2}]$

3   Which one of the following has the same SI unit as acceleration?

A $\dfrac{\text{energy}}{\text{mass}}$ B $\dfrac{\text{velocity}}{\text{area}}$

C $\dfrac{\text{weight}}{\text{mass}}$ D $\dfrac{\text{force}}{\text{length}}$

Questions 4 and 5 refer to the diagram below which shows the profile of a transverse wave.

4   One wavelength is represented by the distance between which two points?
A   EH
B   EF
C   BD
D   AC

5   If the arrow XY represents the direction in which the energy is being propagated, the direction of the motion of point E at the instant shown is

6   A security vehicle is moving towards a stationary person with a speed of 30 m.s^{-1} sounding its alarm which has a frequency of 420 Hz. If the speed of sound is 340 m.s^{-1}, what is the frequency (Hz) heard by the stationary person?

A   371
B   390
C   460
D   476

7   On a cold day, John picks up a knife with a wooden handle. He finds that the steel blade feels colder than the handle. This is because:

A   the metal has a lower specific heat capacity than the wood,
B   the metal is denser than the wood,
C   metal is a better conductor of heat than wood,
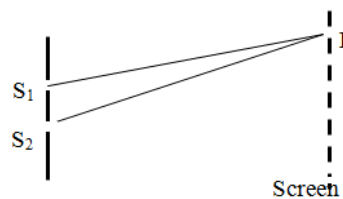D   the metal is colder than the wood.

8   A Galilean telescope is made up of a converging objective lens of 60 cm focal length and a diverging eye lens of 1.5 cm focal length. The magnification of this telescope is:

A   90
B   61.5
C   40
D   4

9   When a converging lens is used as a magnifying glass, the object being looked at will be:

A   Between the lens and the focal point
B   At the focal point
C   Between the focal point and a point, c, at twice the focal distance
D   Beyond the point c

10   The diagram below shows two coherent light sources, S_1 and S_2. Light from these two sources meet to create an interference pattern of alternating light and dark fringes on the screen. P is a bright fringe and the difference between S_1P and S_2P is a whole number of wavelengths $n\lambda$
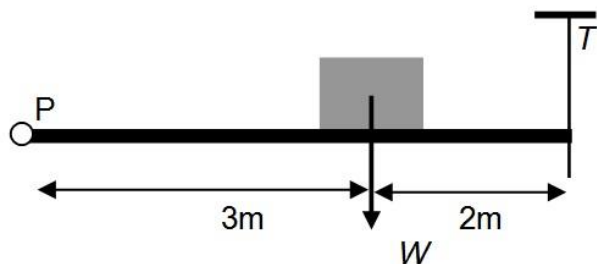(n = 0, 1, 2, 3 . . .)

The path difference to a dark fringe could be:

A $2n\lambda$ B $\dfrac{(2n+1)\lambda}{2}$

C $2(n + 1)\lambda$ D $n(\lambda + 2)$

11   The resultant of two forces at a right angle to each other is 100 N. One of the forces makes an angle of 30° with that resultant. What is the magnitude of this force?
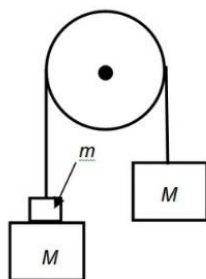
A   115.5 N
B   200 N
C   86.6 N
D   50 N

12 The diagram below shows a uniform beam of weight W, pivoted at point P and held horizontally by a string. It supports a block of weight W as shown.

The tension T in the string is:

A $\dfrac{5W}{2}$ B $\dfrac{11W}{6}$
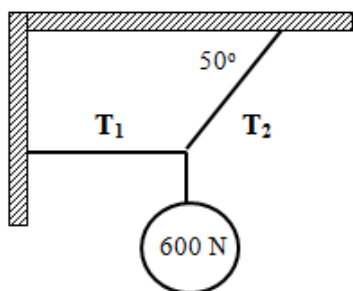
C $\dfrac{10W}{11}$ D $\dfrac{11W}{10}$

13 The pulley system shown below is frictionless and the pulley has negligible mass. When released, the masses have an acceleration *a*.

The value of *m* is:

A $\dfrac{Ma}{2g}$ B $\dfrac{2Ma}{g}$
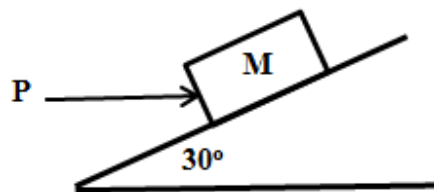
C $\dfrac{2Ma}{g-a}$ D $\dfrac{2Ma}{a-g}$

14 A 600 N metal ball is suspended from two   supports by two cords

.

What is the tension in each cord?

	A	B	C	D
T_1	933 N	715	503	783 N
T_2	715 N	783	783	503 N

15 A box of mass 20 kg rests on a smooth plane inclined at 30° to the horizontal, as shown below.

What is the value of the horizontal force P if the box is not to slide down the plane?

A 10 N
B 100 N
C 86.6 N
D 115.5 N

16 A body falls freely from rest for 6 secs. Find the distance travelled in the last 2 secs.

A 40 m
B 60 m
C 100 m
D 120 m

17 A block of mass M, slides down a smooth surface inclined at 30° to the horizontal. Find the velocity (in m.s^{-1}) of the block after sliding 8 m down the incline

A 11.8
B 8.94
C 12.6
D Need to know the mass M to be able to do this.

18 A 10T locomotive pulls a 50T load of carriages and has an acceleration of 1.5 m.s^{-2}. The same engine with the same power now pulls a load of 20T of carriages. What is now the acceleration (in m.s^{-2}) of the train?

A 2.5
B 3
C 2.35
D 3.75

19 A golfer hits a 51g golf ball, which leaves the club at 80 m.s^{-1}. The club and ball are in contact with each other for 0.006 s. What is the average force exerted on the ball by the club?
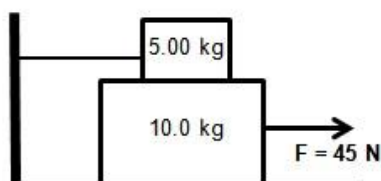
A 6.8 N
B 68 N
C 680 N
D 6 800 N

20 A body of mass m has kinetic energy E. Its momentum is

A $\dfrac{4E^2}{m}$ B $\dfrac{2E}{\sqrt{m}}$

C $2mE$ D $\sqrt{2mE}$

3

21 A truck, which is travelling at a constant speed of 108 km·h⁻¹ passes a traffic officer, who starts off immediately, from rest, with an acceleration of 4 m·s⁻² to chase the truck. He will catch-up with the truck after:

A   24 s
B   20 s
C   15 s
D   10 s

22 A 5.00 kg block is placed on a 10.0 kg block as shown below. A horizontal force of 45.0 N is applied to the 10.0 kg block, and the 5.00 kg block is tied to the wall. The coefficient of kinetic friction between all moving surfaces is 0.200.

Determine the tension in the string, in N

A   5.00
B   50.0
C   10.00
D   7.20

23 Which one of the following is always true for an object moving between two points in the same time?

A   Speed > magnitude of velocity
B   Speed is the same as magnitude of velocity
C   Speed < magnitude of velocity
D   Speed $\geq$ magnitude of velocity

24 A stone is dropped into a well in which the water level is h m below the top. If the speed of sound is c and the acceleration due to gravity is g, then the time to hear the splash of the stone hitting the water from the moment the stone is dropped is:

A $h\left[\sqrt{\dfrac{2}{gh}}+\dfrac{1}{c}\right]$ B $h\left[\sqrt{\dfrac{2}{gh}}-\dfrac{1}{c}\right]$

C $h\left[\dfrac{2}{g}+\dfrac{1}{c}\right]$ D $h\left[\dfrac{2}{g}-\dfrac{1}{c}\right]$

25 The combined frictional force and air resistance on a cyclist is $F = kv$ where v is the velocity and k is a constant of value 4 N.m⁻¹.s. The maximum power the cyclist can generate is 600 W. What is the cyclist's maximum speed in m.s⁻¹ on a level road,?

A   12.25
B   6.122
C   17.31
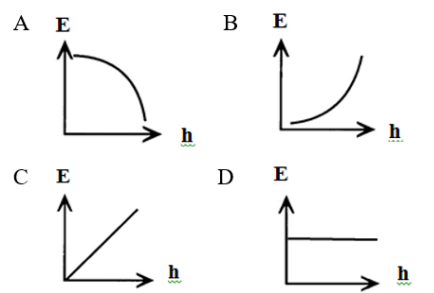D   Unable to calculate unless the air resistance is known

26 A boy of mass 60 kg runs up a set of stairs 5m high in 4 seconds. His average power is:

A   75W
B   480W
C   750W
D   1 200W

27 Two bodies of mass M and 4M are moving in a straight line, each with kinetic energy E. The ratio of their momenta is:

A   4:1
B   1:4
C   1:3
D   1:2

28 A ball of mass M is dropped from a height H. Which ONE of the following graphs correctly shows the variation of the kinetic energy E with the distance fallen h?

29 Peter throws a stone, with a mass of m, from the top of a cliff, H metres above a lake, at a speed of u m.s⁻¹. At what angle must it be thrown so that it hits the water at the maximum speed?

A   Straight up
B   Horizontally out from the cliff
C   Straight down
D   No matter at what angle he throws the stone, it will always reach the lake at the same speed

30 Two identical insulated conductors are charged so that one has a charge of – 6µC and the other a charge of 12µC . They experience a force of F N when placed a distance d m apart. They are now briefly brought into contact with each other and returned to their original positions. The magnitude of the force on each is now:

A $\dfrac{9F}{8}$ B   F
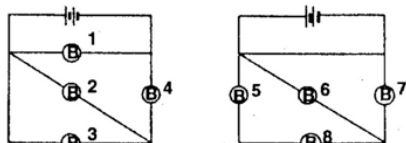
C $\dfrac{F}{4}$ D $\dfrac{F}{8}$

31 Seven capacitors each of capacitance 2 µF are to be connected together to obtain a capacitance of $\dfrac{10}{11}$ µF.

Which one of the following combinations will enable you to do this?

A   5 in parallel and 2 in series
B   4 in parallel and 3 in series
C   3 in parallel and 4 in series
D   2 in parallel and 5 in series

32   Three charges are placed along the X-axis. Charge A is a +18 nC charge placed at the origin, 0m mark. Charge B is a – 27 nC charge placed at the 0.6m mark. Where along the axis must a negative charge C be placed in order to be in equilibrium? At the:

A   2.67 m mark
B   0.27 m mark
C   – 0.27 m mark
D   – 6.27 m mark

33   The circuits below have identical batteries and bulbs.

Which of the bulbs burns equally brightly?

A   2, 3, 6 and 8
B   4 and 7
C   2 and 3
D   4, 5 and 8

34   A constant current of 2 A flows for 3 min through a conductor. The total charge that passes through the conductor is, in C
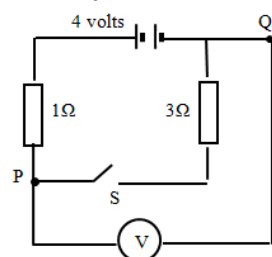
A   6
B   60
C   120
D   360

35   N identical cells of emf E and internal resistance r, are connected in parallel. This combination is then connected to an external resistance R. The current in R is:

A $\dfrac{\mathcal{E}}{R+r}$

B $\dfrac{\mathcal{E}}{R+Nr}$

C $\dfrac{\mathcal{E}}{R+\dfrac{r}{N}}$

D $\dfrac{\mathcal{E}}{R+\dfrac{N}{r}}$

36   The potential difference (PD) between the terminals of a cell is equal to the emf when:

A   The cell is not supplying any current
B   The cell is connected in parallel in a circuit
C   The cell is connected in series in a circuit
D   All of the above

The following information is to be used for answering question 37 and question 38.

The battery has no internal resistance and resistors have the values shown. S is a switch (shown open) and V is a high resistance voltmeter connected between P and Q as shown.

37   What is the reading on the voltmeter when switch S is open?

A   0 volt
B   1 volt
C   3 volt
D   4 volt

38   What is the reading on the voltmeter when switch S is closed?
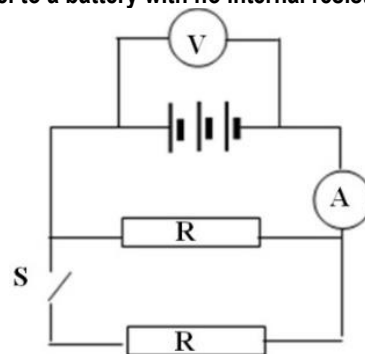
A   4 volt
B   3 volt
C   4/3 volt
D   0 volt

39   A galvanometer has a resistance of 100 Ω. It gives a full scale deflection when a potential difference of 50 mV is applied across its terminals. The resistance of the shunt that enables it to read up to 5A will be:

A   0.01 Ω
B   10.0 Ω
C   0.20 Ω
D   0.5 Ω

40   The RMS value of alternating current which produces heat in a given resistor at twice the rate as a direct current of 3A is in amperes:

A   1.5   B $\sqrt{6}$
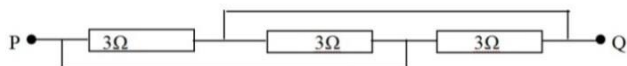
C $2\sqrt{3}$ D $3\sqrt{2}$

41   The circuit shows two identical resistors connected in parallel to a battery with no internal resistance

How do the readings on the voltmeter V and the ammeter A change when the switch S is closed

	Voltmeter	Ammeter
A	increases	decreases
B	stays the same	increases
C	decreases	increase
D	stays the same	decreases

5

42 In the circuit shown below the resistance, in ohms (Ω) between the points P and Q is:
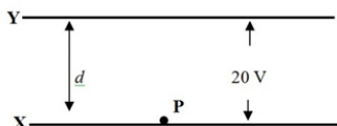

A $\dfrac{3}{2}$ B 9

C $\dfrac{2}{3}$ D 1

43 Two bulbs are marked 100 W, 200 V and 50 W, 200 V respectively. If the bulbs are connected in series, then the ratio of their respective power output is:

A   1:2
B   1:1
C   2:1
D   1:4

44 The diagram below shows two parallel plates a distance *d* apart with a potential difference of 20V between them with Y at the higher potential. A small particle P of mass 6×10^{-12} kg carrying charge of -9 µC is released from plate X. Neglect   gravitational effects.

The speed *u* with which P reaches plate Y is:

A   7 746 m.s^{-1}
B   1 225 m.s^{-1}
C   30 m.s^{-1}
D   unable to calculate it unless *d* is known,

45 What is the electric field strength required to just hold an oil drop with a mass of 5.23×10^{-19} kg if it is carrying a charge of one electron 1.6×10^{-19} C?

A   31.2 V· m^{-1}
B   12.3 V· m^{-1}
C 23.1×10^{-4} V· m^{-1}
D 3.12×10^{-4} V· m^{-1}

46 Electrons are accelerated from rest through a small potential difference *V* and reach a speed *u*. The ratio of the charge of the electron to its mass $(\frac{e}{m})$ is:

A $\dfrac{u}{V}$ B $\dfrac{V}{u}$

C $\dfrac{u^2}{2V}$ D $\dfrac{2u^2}{V}$

47 A Uranium 238 nucleus ($^{238}U_{92}$) decays by emitting the following particles: α β β α β in turn. The isotope that remains has the following mass and atomic number:

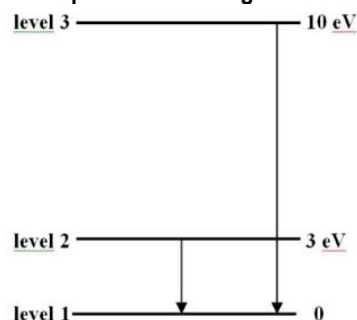|	Mass	Number
A	230	91
B	237	84
C	234	90
D	230	88

48 Radiation of frequency 10^{15} Hz shines on the surface of a metal whose work function is 1 eV (1.6×10^{-19} J). The retarding potential which just prevents the ejection of photo-electrons is:

A   1 V
B   3 V
C   3.84 V
D   5 V

49 A proton and an alpha particle are accelerated through the same potential difference. The ratios of their de-Broglie wavelengths ($\dfrac{\lambda_p}{\lambda_\alpha}$) will be:

A   1   B 2

C $2\sqrt{2}$ D $\dfrac{2}{\sqrt{2}}$

50 The diagram below shows three of the energy levels of an atom. A transition from level 2 to level 1 results in the emission of a photon of blue light.

A transition from level 3 to level 1 could result in the emission of a photon of:
A γ-radiation
B   ultra-violet light
C   red light
D   infra-red

51 Which one of the following groups of elements are classified as halogens?

A   Li, Na, K
B   Ne, Ar, Kr
C   F, Cℓ, Br
D   Si, Ge, As

52 There are … electrons, …protons and … neutrons in an atom of $^{235}_{92}U$.

A   143, 143, 235
B   92, 92, 235
C   92, 92, 143
D   143, 143, 92

53 Which one of the following electron configurations represents an ion of an alkali metal?

A $1s^2 2s^2 2p^6 3s^1$
B $1s^2$
C $1s^2 2s^2$
D $1s^2 2s^2 2p^5$

54 Element A with three valence electrons combines with element B with six valence electrons. The compound formed is most likely to be:

A Covalent, with the formula A_3B_6
B Covalent, with the formula A_2B_3
C Ionic, with the formula A_2B_3
D Ionic, with the formula A_3B_2

55 Each of the substances below is formed by attractive forces between two ions. In which one of the substances do the constituent ions have the same electron configuration?

A KBr
B Na_2S
C $MgC\ell_2$
D $CaC\ell_2$

56. Which one of the ions below will produce a red flame when vapourised in a Bunsen flame?

A $Ca^{2+}(aq)$
B $Na^+(aq)$
C $Zn^{2+}(aq)$
D $K^+(aq)$

57 Solid iodine sublimes easily. The intermolecular forces present in iodine are …

A London forces.
B hydrogen bonding.
C ion-dipole forces.
D dipole-dipole forces.

58 Which one of the following chemical equations represents an endothermic reaction?

A $NH_4NO_3(s) + H_2O(\ell) \rightarrow NH_4^+(aq) + NO_3^-(aq)$ $\Delta H > 0$
B $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$ $\Delta H < 0$
C $Zn(s) + 2HC\ell(aq) \rightarrow ZnC\ell_2(aq) + H_2(g) + heat$
D $H_2(g) + C\ell_2(g) \rightarrow 2HC\ell(g)$ $\Delta H = -131$ kJ·mol^{-1}

59 Freshly prepared pancake batter (milk, flour and eggs) is always allowed to stand for some time before baking to allow the batter to thicken. The reason the batter thickens is:

A Water evaporates from the mixture
B Disulfide bonds form between proteins in the flour
C Unsaturated lipids in the egg become saturated
D All of the above

60 Which one of the following statements is FALSE when used in connection with solutions?

A solution ...

A is homogeneous.
B exists in a single phase.
C has definite properties.
D can usually be separated into components.

61 What are the coefficients respectively when the following equation is balanced?

… $PH_3 + … O_2 \rightarrow … P_2O_5 + … H_2O$

A 2, 2, 1, 3
B 2, 1, 3, 4
C 2, 3, 1, 2
D 2, 4, 1, 3

62 Elements in the same group of the periodic table have similar chemical properties.

This similarity can be explained in terms of the:

A Principal energy levels
B Atomic mass
C Atomic number
D Number of valence electrons

63 The atomic mass of hydrogen is 1.008 amu. Which one of the following best explains why this value is not a whole number?

A Hydrogen only exists as a diatomic molecule.
B The mass of hydrogen is the sum of the masses of the protons and electrons in the atom.
C The mass of a proton is not exactly equal to 1 amu.
D Hydrogen has more than one isotope.

64 Which one of the following represents 1 mole of a substance?

A 16 g oxygen gas
B 2 g hydrogen gas
C 22,4 dm^3 copper
D 22,4 cm^3 nitrogen gas

65 How many hydrogen atoms are there in 48.0 g of CH_4?

A 1.81×10^{23}
B 7.22×10^{24}
C 6.02×10^{23}
D 1.20×10^{25}

66 Applying VSEPR theory, a molecule in which there are three bonding domains but no lone pairs around the central atom is most likely to have … geometry.

A. trigonal planar
B. tetrahedral
C. linear
D. V-shaped

67 The bond energy of a C – Cℓ bond is 338 kJ·mol^{-1} whereas the bond energy of a C – I bond is 238 kJ·mol^{-1}. The difference in bond energy exists because …

A the bond length of the C – Cℓ bond is greater than that of the C – I bond.
B chlorine is more electronegative than iodine.
C the bond length of the C – I bond is greater than that of the C – Cℓ bond.
D the chlorine atom is bigger than the iodine atom.

68 *One mole of any gas occupies the same volume at the same temperature and pressure.*

The above statement is known as …
A Charles's law.
B Gay Lussac's law.
C Avogadro's law.
D the ideal gas law.

69 One mole of a gas, SEALED in a container, has volume V at temperature T and pressure p. If the pressure is increased to $3p$, the ratio between the volume and temperature (V : T) is:

A 1 : ⅓

B 3 : 1

C ⅓ : 3

D 1 : 3

70 A real gas would act most ideal at:
A 1 atm and 273 K
B 10 atm and 547 K
C 10 atm and 273 K
D 0.5 atm and 546 K

71 Decompression sickness, or "the bends", occurs when deep-sea divers return too rapidly from the high-pressure ocean depths to the surface. This sickness results from:

A. Too little oxygen in the bloodstream at normal pressure
B. Higher solubility of nitrogen and oxygen at higher pressure
C. Lower solubility of nitrogen and oxygen at higher pressure
D. None of the above

72 Chemical analysis shows that the composition of a compound containing carbon, hydrogen, chlorine, and oxygen is as follows: 37.84% C, 2.12% H, 55.84% Cℓ, and 4.20% O
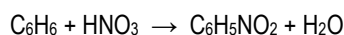What is its empirical formula?

A CHCℓO
B $C_2HCℓO_4$
C $C_{12}H_8CℓO$
D $C_{12}H_8Cℓ_6O_4$

73 Vitamin C, a compound found in many food items, has the empirical formula $C_3H_4O_3$. If the molar mass of vitamin C is 176 g·mol^{-1}, which one of the following is the correct molecular formula?

A $C_3H_4O_3$
B $C_6H_8O_6$
C $C_6H_{12}O_6$
D C_2HO_2

74 15.6 g of benzene (C_6H_6) is mixed with excess HNO_3 to prepare nitrobenzene ($C_6H_5NO_2$) according to the following balanced equation:

$$C_6H_6 + HNO_3 \rightarrow C_6H_5NO_2 + H_2O$$

After completion of the reaction there are 15.6 g of nitrobenzene produced. What is the percent yield of nitrobenzene?
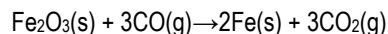
A 71.2%
B 63.4%
C 58.9%
D 47.6%

75 In the chemical reaction
$$H_2S + MnO_4^- \rightarrow Mn^{2+} + S + 2H^+,$$

the substance that is oxidised is:

A Sulphur
B The manganese ion
C The permanganate ion
D Hydrogen sulphide

76 The equation below represents a chemical reaction.

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$$

Consider the following statements about this reaction:

I The oxidation number of carbon changes from +2 to +4.
II The oxidation number of iron changes from +2 to 0.
III Carbon monoxide acts as an oxidising agent.

Which of the statement(s) above is/are correct?

A I only
B II only
C I and III only
D II and III only

77 The acronym IUPAC stands for:

A International Union of Physics and Chemistry
B International Union of Physics and Applied Chemistry
C International Union for Peace and Comradeship
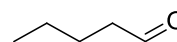D International Union of Pure and Applied Chemistry

78 The plastics industry in South Africa manufactures synthetic polymers by addition reactions of monomers. Which one of the following plastics is correctly matched to its most common use?

A Polyethylene for plastic coffee cups
B Polyvinyl chloride (PVC) for non-stick coatings
C Polystyrene for plastic bottles
D None of the above

79 The name and formula of the ester formed when propanoic acid reacts with butan-1-ol are, respectively,

A butyl propanoate, $CH_3CH_2CH_2COOCH_2CH_2CH_3$
B butyl propanoate, $CH_3CH_2COOCH_2CH_2CH_2CH_3$
C propyl butanoate, $CH_3CH_2CH_2COOCH_2CH_2CH_3$
D propyl butanoate, $CH_3CH_2COOCH_2CH_2 CH_2CH_3$

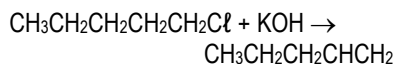**80** Consider the structure of a compound below.

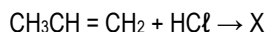The compound is an example of an:

A Ester
B Amide
C Aldehyde
D Alcohol

81 The equation below represents an organic reaction.

$CH_3CH_2CH_2CH_2CH_2C\ell + KOH \rightarrow$
$CH_3CH_2CH_2CHCH_2$

This reaction is an example of:

A Dehydration
B Fermentation
C Dehydrohalogenation
D Addition

82 In the reaction below, X is the major organic product formed.

$$CH_3CH = CH_2 + HC\ell \rightarrow X$$

Which one of the following compounds is represented by X?

A $CH_3CH_2CH_2C\ell$
B $CH_3CHC\ell CH_3$
C $CH_3CHC\ell CH_2C\ell$
D $CH_2C\ell CH = CH_2$

83 The reaction $A \rightleftharpoons B$ has an equilibrium constant of $K_c=10^{-4}$. Which one of the following statements is always correct for this reaction?

A The reaction will have 50% product B and 50% reactant A at equilibrium.
B The reaction is very favourable and will have mostly product B at equilibrium.
C The reaction is unfavourable and will not have very much product B at equilibrium.
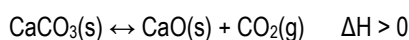D The equilibrium constant only relates to the speed of a reaction and not to the amount of product formed.

84 The balanced equations for three reactions at equilibrium, each in a closed container, are given below.

(i) $C_2H_4(g) + H_2(g) \rightleftharpoons C_2H_6(g)$
(ii) $Fe_3O_4(s) + 4H_2(g) \rightleftharpoons 3Fe(s) + 4H_2O(g)$
(iii) $SO_3(g) + NO(g) \rightleftharpoons NO_2(g) + SO_2(g)$

In which reaction(s) will the equilibrium position shift when the volume of the reaction vessel is decreased at constant temperature?

A (i) only
B (i) and (ii) only
C (i) and (iii) only
D (i), (ii) and (iii)

85 Two and a half grams (2.5 g) of calcium carbonate is sealed into a 250 cm³ tube and heated to a constant temperature. The equation for the reaction is:

$$CaCO_3(s) \leftrightarrow CaO(s) + CO_2(g) \quad \Delta H > 0$$

After equilibrium was reached 1.7 g of $CaCO_3$ remained. What is the value of the equilibrium constant, K_c, at this temperature?

A. 0.015
B. 0.001
C. 0.032
D. None of the above

86 The compound phenolphthalein is most commonly used as an …

A explosive.
B indicator.
C antiseptic.
D emetic.

87 After addition of sodium metal to water, the water will …

A feel soapy and turn litmus blue.
B feel sticky and turn litmus red.
C have high levels of dissolved oxygen and turn litmus blue.
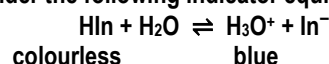D have high levels of dissolved carbon dioxide and turn litmus red.

88 When solid K_2CO_3 is added to water, the pH …

A becomes less than 7 because of hydrolysis of K^+.
B becomes greater than 7 because of hydrolysis of K^+.
C becomes greater than 7 because of hydrolysis of CO_3^{2-}.
D becomes less than 7 because of hydrolysis of CO_3^{2-}.

89 Consider the reaction of $CH_3COOH(aq)$ with $NaOH(aq)$. Which one of the following net equations accounts for the pH of the salt?

A $CH_3COOH(aq) + NaOH(aq) \rightleftharpoons NaCH_3COO(aq) + H_2O(\ell)$
B $H^+(aq) + OH^-(aq) \rightleftharpoons H_2O(\ell)$
C $CH_3COO^-(aq) + H_2O(\ell) \rightleftharpoons CH_3COOH(aq) + OH^-(aq)$
D $CH_3COOH(aq) + OH^-(aq) \rightleftharpoons CH_3COO^-(aq) + H_2O(\ell)$

90 Consider the following indicator equilibrium:
$$HIn + H_2O \rightleftharpoons H_3O^+ + In^-$$
colourless   blue

What is the effect of adding $HC\ell$ to a blue sample of this indicator?

	Shift of equilibrium position	Colour change
A	To the right	More blue
B	To the left	Less blue
C	To the left	More blue
D	To the right	Less blue

91 A drop of 2 in the pH level in an aquarium would mean that the acidity, measured as $[H^+]$, had changed by a factor of:

A 2
B 10
C 100
D 1000

92 The following equation represents the neutralization reaction of oxalic acid with sodium hydroxide:

$$C_2H_4O_4 + 2NaOH \rightarrow C_2O_4Na_2 + 2H_2O$$

If it takes 35 ml of an oxalic acid solution of concentration 0.21 mol·ℓ^{-1} to neutralize 20 mℓ of a sodium hydroxide solution, what is the concentration of the sodium hydroxide solution?

A 0.10 mol·ℓ^{-1}
B 0.369 mol·ℓ^{-1}
C 0.735 mol·ℓ^{-1}
D 0.210 mol·ℓ^{-1}

93 Consider the cell notation of the galvanic cell below.

Zn│Zn²⁺‖Cu²⁺│Cu

Which one of the following statements regarding this cell is TRUE?

A   Copper is formed at the cathode.
B   Copper is formed at the anode.
C   Zinc is formed at the anode.
D   Zinc is formed at the cathode.

94 Consider the following statements regarding electrochemical cells:

(i)   The cathode of a galvanic cell is positive.
(ii)   Electroplating of metals occur at the cathode.
(iii) Reduction takes place at the positive electrode of an electrolytic cell.

Which of the above statements is/are true?

A   (i) only
B   (i), (ii) and (iii)
C   (ii) only
D   (iii) only

95 Which one of the following is the product formed in the Haber process?

A   Nitrogen
B   Ammonia
C   Nitric acid
D   Sulphuric acid

96 The Ostwald process was developed in 1902 by Nobel prize winner Wilhelm Ostwald. The overall process may be summarised as:

A $N_2 (g) + 3H_2 (g) \rightarrow 2NH_3 (g)$
B $NaNH_2 (s) + H_2O \rightarrow NH_3 (aq) + NaOH (aq)$
C $NH_3 + HNO_3 \rightarrow NH_4NO_3$
D $NH_3 (g) + 2O_2 (g) \rightarrow HNO_3 (aq) + H_2O$

97 Which of the following is a chemical name for the common painkiller aspirin?

A   Isopropyl amide
B   Butyl ethanoate
C   Ethyl butanoate
D   Acetylsalicylic acid

98 The natural gemstones ruby and sapphire, are both composed largely of:

A $KAl(SO_4)_2 \cdot 12H_2O$
B Fe_2O_3
C $Be_3Al_2(SiO_3)_6$
D Al_2O_3

99 Which important technique used by Rosalind Franklin and Maurice Wilkins contributed significantly to the determination of the structure of DNA?

A   Mass spectrometry
B   DNA fingerprinting
C   X-ray diffraction
D   Polymerase chain reaction (PCR)

100 Half of the 2018 Nobel prize in Chemistry was awarded to Frances Arnold from the USA for:

A   Producing enzymes through directed evolution that can be used to manufacture everything from biofuels to pharmaceuticals.
B   Developing phage display, a method where a virus that infects bacteria can be used to evolve new proteins
C   Synthesising antibodies that can combat autoimmune diseases and in some cases cure metastatic cancer
D   Developing phage display for the directed evolution of antibodies, with the aim of producing new pharmaceuticals

~The End ~