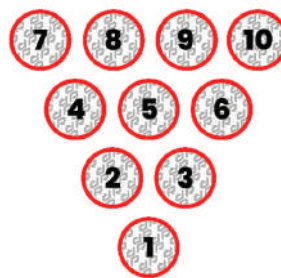


ALL QUESTIONS WORTH 4 POINTS

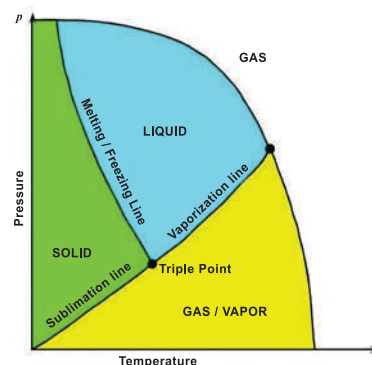
1. Bowling is a sport where players throw balls and try to knock down pins. In high-level play, professionals are almost always able to knock down all the pins within two throws. Sometimes, on their first throw, two remaining pins stand far apart from one another. It is extremely difficult to knock down the two remaining pins with one throw, and doing so is known as a "killer shot".



When the pins numbered 6 and 7 remain standing after the first throw, it is known as a 6-7 split, which occurs somewhat frequently. Bob wants to be a professional bowler in the future, and decides to practice achieving a "killer shot" on the 6 and 7 pins. He throws the ball at the 6-pin, hitting it on the left. The ball bounces off the 6-pin, but does not hit the 7-pin, instead passing by to the right of the 7-pin. What adjustment should Bob make, so that the ball will bounce off the 6-pin and hit the 7-pin?

- A) Throw the ball at a higher speed.
- B) Use a ball with less mass.
- C) Throw the ball to hit the 6-pin on its right instead of its left.
- D) Throw the ball to hit the 6-pin directly on its front.

2. The "triple point" refers to the exact temperature and pressure where water can exist as three states at the same time. This varies from material to material, but in water, the triple point is at 273.16K, or 0.16°C, and a pressure of 0.006 atm. The diagram of a closed system containing water is shown above. Based on the diagram, which of the following statements is correct?



- A) At -5°C and the same pressure as the triple point, the system consists of mostly water vapour.
- B) From the triple point, decreasing the temperature alone will result in water vapour being formed.
- C) From the triple point, increasing the pressure alone will result in liquid water being formed.
- D) At 1°C and the same pressure as the triple point, the system consists of mostly ice.

3. Shower heaters in many countries make use of electricity to generate the heat needed to make the shower water warm. Typically, the specific heat capacity of water can be assumed to be $4.2\text{Jg}^{-1}\text{K}^{-1}$. Your friend, Tim, has an electric shower rated at 8 kilowatts. When he showers, every second, 110g of water passes through the shower. Given that the initial water temperature is 20 degrees, what temperature will be the water that he showers with?



- A) Between 25.0°C and 29.9°C B) Between 30.0°C and 34.9°C
C) Between 35.0°C and 39.9°C D) Between 20.0°C and 24.9°C
4. When you are standing on a road, you notice a car approaching you. It sounds a horn loudly at you to warn you to stay off the road. You notice that as the car approaches you, the horn sounds high pitched, but as it drives off and away from you, the horn sounds low pitched. You conclude that this is due to a difference in the properties of the sound wave reaching you. What best describes why the horn sounds different?
- A) The frequency of the sound wave received is lower when the car is approaching you but higher when the car is driving away.
B) The amplitude of the sound wave received is higher when the car is approaching you but lower when the car is driving away.
C) The frequency of the sound wave received is higher when the car is approaching you but lower when the car is driving away.
D) The amplitude of the sound wave received is lower when the car is approaching you but higher when the car is driving away.
5. A cat is enjoying a nap on a signboard that is 1 metre tall. It sees a mouse 2 metres away from the base of the signboard, and jumps off the signboard with a horizontal velocity of 1 m/s. Given that the gravitational field strength is 9.81 N/kg, what is the time taken for the cat to land on the ground?

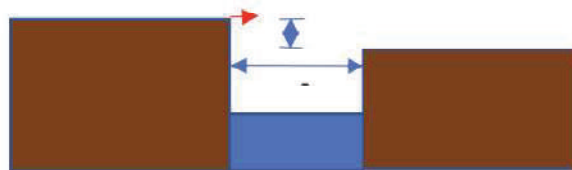


- A) 0.64 s B) 0.45 s C) 0.75 s D) 0.87 s

6. When driving on the highway, it is important to obey the speed limit. Driving too fast can lead to serious injuries if you lose control of the vehicle. Drivers that exceed the speed limit will be punished, such as being made to pay a fine. It is difficult to check the speeds of all vehicles on the highway at the same time. On one particular highway, the speed limit is 100 km/h, and any driver that exceeds 100 km/h at any point along the highway will be considered speeding. This strategy was used to obtain information about the speeds of cars travelling on the highway: Toll booths are placed 100 km apart along the highway. The time that a car passes through each toll booth is recorded. If a car reaches the next toll booth in less than 1 hour after passing through the previous toll booth, the driver will be fined for speeding. Which statement correctly describes the advantages and/or disadvantages of this strategy?

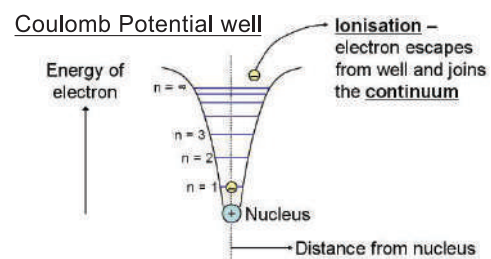


- A) Not all drivers that were actually speeding were fined for speeding, and not all drivers that were fined for speeding were actually speeding.
- B) All drivers fined for speeding were actually speeding, and all drivers that were actually speeding were fined for speeding.
- C) All drivers that were actually speeding were fined for speeding, but not all drivers that were fined for speeding were actually speeding.
- D) All drivers fined for speeding were actually speeding, but not all drivers that were actually speeding were fined for speeding.
7. Wile E. Coyote chases the Road Runner over a cliff at a constant velocity. However, Road Runner stops right before he reached the end of the cliff, but Wile E. Coyote was not able to stop on time. If the beginning of the next cliff is L meters away from the edge of the first cliff, and it is H meters below the first cliff, what minimum speed that Wile should have so that he can safely land on the tip of next hill without falling into the river?



- A) $v_0 = L\sqrt{\frac{g}{2H}}$ B) $v_0 = L\sqrt{\frac{g}{H}}$ C) $v_0 = L\sqrt{\frac{2g}{H}}$ D) $v_0 = 2L\sqrt{\frac{g}{H}}$

8. The potential energy of electrons near a positively charged nucleus can be described by a Coulomb potential well, shown in the diagram, with electrons behaving as quantum particles.



Which statement is incorrect?

- A) Electrons bound to the nucleus have a negative total energy.
- B) The kinetic energy of the electron in the ground state will not be zero at 0K due to the zero point energy.
- C) Ionization occurs when the total energy of the electron reaches zero.
- D) In the ground state, all electrons can be found at the lowest energy level, $n=1$.

9. **Ball bearings are very useful in the engineering and design of devices. Ball bearings can help reduce friction between rotating or sliding parts of a machine, allowing for more efficiency and reduced wear and tear in a machine's moving parts. Two ball bearings, one made of aluminium and the other made of steel, were found in a workshop. The ball bearings were of the same radius, but the steel ball bearing had a spherical hole in its centre, such that it weighs exactly the same as the aluminium ball bearing. Which of the following is not a possible way of differentiating the ball bearings?**



- A) Placing both ball bearings into a water tank to measure their densities
- B) Heating the ball bearings unevenly to measure their heat conductivity
- C) Spinning both of the ball bearings with the same force and measuring their angular velocity
- D) Passing a current through both of the ball bearings to measure their electrical conductivity

10. **In fluid dynamics, viscosity is a measure of how resistant a fluid is to a change in its shape, or more intuitively, its opposition to flow. Fluids with different viscosities exhibit different physical properties. Shawn wanted to examine how the viscosity of a gas or liquid might change when its temperature increases.**



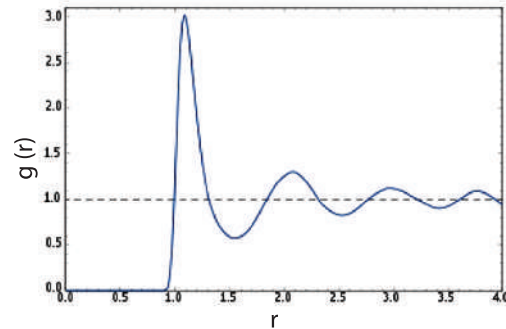
Which of the following statements is true?

- A) When a gas is heated, the intermolecular forces of attraction between particles will be weakened, hence its viscosity would decrease.
- B) When a gas is heated, the particles in the gas will collide with each other more frequently, hence its viscosity would increase.
- C) When a liquid is heated, the intermolecular forces of attraction between particles will be strengthened, hence its viscosity would increase.
- D) When a liquid is heated, it remains a liquid hence its viscosity stays constant.

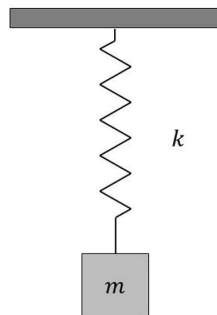
11. The pair distribution function of a material consisting of atoms describes where the atoms are located in a material. It is defined at a radial distance r from an origin point as

$$g(r) = \frac{dn(r)}{dv(r)} \frac{1}{\langle \rho \rangle}$$

where dn is the number of atoms in an infinitesimally thin spherical shell from r to $r + dr$, and dv is the volume of that shell, and $\langle \rho \rangle$ is the average volume density of atoms in the whole material. The graph shows an example of $g(r)$ for an amorphous material. Based on the equation provided and the graph shown, which statement is correct?



- A) The diameter of an atom is around 1.0
 B) The SI units of $g(r)$ is m^{-3}
 C) $g(r)$ tends to zero as r increases to infinity
 D) The value of $g(r)$ can be negative
12. The ISS (International Space Station) is a space station moving in a circle around the earth. We have a vertical mass-spring system inside the ISS.



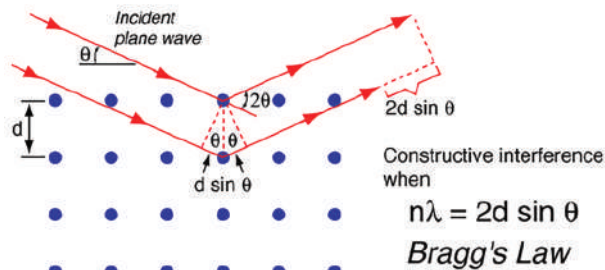
Alice, Bob, Cole and Diana make the following statements about the mass-spring system:

- A: "The initial deformation of the spring is mg/k , where g is the gravitational acceleration at the ISS height above the surface."
 B: "Because the ISS is further away from the Earth, the block's mass decreases."
 C: "The period of oscillations of the system will be the same as on Earth."
 D: "If the spring was a string, the block could oscillate as a gravitational pendulum."

How many of the statements above are false?

- A) 2 B) 1 C) 3 D) 0

13. An X-ray diffraction machine uses an X-ray to determine the distance between two atomic planes in a crystalline material. The behaviour of the X-rays obey Bragg's Law, where a peak in the signal will be observed for a certain value of θ when $2d \sin\theta = n\lambda$. Where d is the distance between two atomic planes, λ is the wavelength of the X-rays used, and n has to be an integer value. If one knows the value of λ , one can use the value of θ of the observed peak to find the value of d , the distance between two atomic planes. John wants to use an X-ray of energy 180 eV to measure exactly the distance between two atomic planes, which he estimates to be between 0.5 and 1 nm. However, he found that he was unable to do so. Which statement best explains why?

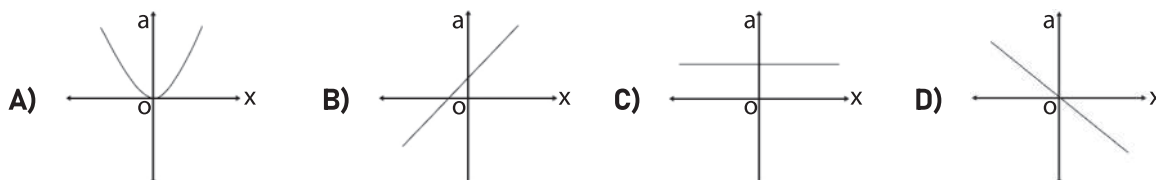


- A) The wavelength of the X-ray used is too small.
 B) The wavelength of the X-ray used is too large.
 C) The value of θ is close to zero.
 D) The value of θ is more than 90° .
14. The radioactive decay of uranium follows a first-order relationship, that is, the rate of decay is proportional to the amount of uranium. The mathematical equation for the rate of decay can be given by:

$$\frac{dU}{dt} = AU$$

Where U is the amount of uranium and t is the time elapsed. A is a constant. Which statement is incorrect?

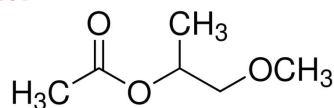
- A) The graph of U against t follows the graph for exponential decay.
 B) The constant A is always negative.
 C) The half-life of the decay of uranium is a constant.
 D) As time passes, the rate of decay of uranium remains constant, as it is not dependent on time t .
15. The system shown consists of a block suspended from the ceiling by a spring. The block is given a small displacement, and subsequently exhibits simple harmonic motion. Which graph represents the plot of acceleration against displacement?



16. Transition metals form many coloured compounds. Before synthetic dyes were invented, many artists used compounds of transition metals as paint. Even today, soldiers camouflage their faces with chromium(III) oxide. Which of these compounds is least likely to be coloured?



- A) $\text{Cu}(\text{NH}_3)_6\text{Br}_2$ B) $\text{Ra}(\text{BrO}_3)_2$ C) $\text{Au}(\text{PtF}_6)_2$ D) $\text{Mg}_3(\text{VO}_4)_2$
17. In the global race to produce advanced semiconductor chips, some countries have suggested restricting the supply of important chemicals to the semiconductor industries of their rivals. An important chemical in photolithography, a key step in producing semiconductor chips, is propylene glycol monomethyl ether acetate.



Which statement about propylene glycol monomethyl ether acetate is incorrect?

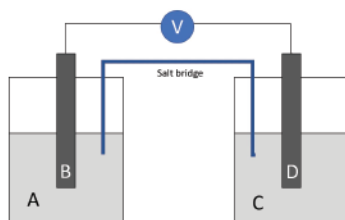
- A) Propylene glycol monomethyl ether acetate contains polar bonds.
 B) Molecules of propylene glycol monomethyl ether acetate can form hydrogen bonds with each other.
 C) Propylene glycol monomethyl ether acetate contains 1 chiral centre.
 D) 1 molecule of propylene glycol monomethyl ether acetate contains 2 pi electrons only.
18. A student electrolyzed an aqueous solution containing 1 mol/dm³ each of Al³⁺, Ag⁺, and Fe²⁺ with a voltage source of 5.0 V. Which statement best explains what will be observed at the cathode? The standard reduction potentials of some species are shown.

TABLE 18.1 Standard Reduction Potentials in Water at 25°C

Potential (V)	Reduction Half-Reaction
+2.87	$\text{F}_2(\text{g}) + 2 \text{e}^- \longrightarrow 2 \text{F}^-(\text{aq})$
+1.51	$\text{MnO}_4^-(\text{aq}) + 8 \text{H}^+(\text{aq}) + 5 \text{e}^- \longrightarrow \text{Mn}^{2+}(\text{aq}) + 4 \text{H}_2\text{O}(\text{l})$
+1.36	$\text{Cl}_2(\text{g}) + 2 \text{e}^- \longrightarrow 2 \text{Cl}^-(\text{aq})$
+1.33	$\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 14 \text{H}^+(\text{aq}) + 6 \text{e}^- \longrightarrow 2 \text{Cr}^{3+}(\text{aq}) + 7 \text{H}_2\text{O}(\text{l})$
+1.23	$\text{O}_2(\text{g}) + 4 \text{H}^+(\text{aq}) + 4 \text{e}^- \longrightarrow 2 \text{H}_2\text{O}(\text{l})$
+1.06	$\text{Br}_2(\text{l}) + 2 \text{e}^- \longrightarrow 2 \text{Br}^-(\text{aq})$
+0.96	$\text{NO}_3^-(\text{aq}) + 4 \text{H}^+(\text{aq}) + 3 \text{e}^- \longrightarrow \text{NO}(\text{g}) + 2 \text{H}_2\text{O}(\text{l})$
+0.80	$\text{Ag}^+(\text{aq}) + \text{e}^- \longrightarrow \text{Ag}(\text{s})$
+0.77	$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \longrightarrow \text{Fe}^{2+}(\text{aq})$
+0.68	$\text{O}_2(\text{g}) + 2 \text{H}^+(\text{aq}) + 2 \text{e}^- \longrightarrow \text{H}_2\text{O}_2(\text{aq})$
+0.59	$\text{MnO}_4^-(\text{aq}) + 2 \text{H}_2\text{O}(\text{l}) + 3 \text{e}^- \longrightarrow \text{MnO}_2(\text{s}) + 4 \text{OH}^-(\text{aq})$
+0.54	$\text{I}_2(\text{s}) + 2 \text{e}^- \longrightarrow 2 \text{I}^-(\text{aq})$
+0.40	$\text{O}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{l}) + 4 \text{e}^- \longrightarrow 4 \text{OH}^-(\text{aq})$
+0.34	$\text{Cu}^{2+}(\text{aq}) + 2 \text{e}^- \longrightarrow \text{Cu}(\text{s})$
0 [defined]	$2 \text{H}^+(\text{aq}) + 2 \text{e}^- \longrightarrow \text{H}_2(\text{g})$
-0.28	$\text{Ni}^{2+}(\text{aq}) + 2 \text{e}^- \longrightarrow \text{Ni}(\text{s})$
-0.44	$\text{Fe}^{2+}(\text{aq}) + 2 \text{e}^- \longrightarrow \text{Fe}(\text{s})$
-0.76	$\text{Zn}^{2+}(\text{aq}) + 2 \text{e}^- \longrightarrow \text{Zn}(\text{s})$
-0.83	$2 \text{H}_2\text{O}(\text{l}) + 2 \text{e}^- \longrightarrow \text{H}_2(\text{g}) + 2 \text{OH}^-(\text{aq})$
-1.66	$\text{Al}^{3+}(\text{aq}) + 3 \text{e}^- \longrightarrow \text{Al}(\text{s})$
-2.71	$\text{Na}^+(\text{aq}) + \text{e}^- \longrightarrow \text{Na}(\text{s})$
-3.05	$\text{Li}^+(\text{aq}) + \text{e}^- \longrightarrow \text{Li}(\text{s})$

- A) Solid Ag will first be formed only.
- B) Solid Ag will first be formed, followed by solid Fe, then finally solid Al.
- C) Solid Al will first be formed, followed by solid Fe, then finally solid Ag.
- D) Solid Ag will first be formed, followed by solid Fe. Al will not be formed.

19. A student constructed the following electrochemical cell under standard conditions, shown below:



He measured the cell potential using a voltmeter and found it to be 0.78 V. What are the identities of A, B, C and D? The standard reduction potentials of selected species are shown below:

	Half Reaction	potential
↑ increasing strength as an oxidizing agent	$F_2 + 2e^- \rightleftharpoons 2F^-$	+2.87 V
	$Pb^{4+} + 2e^- \rightleftharpoons Pb^{2+}$	+1.67 V
	$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$	+1.36 V
	$Ag^+ + 1e^- \rightleftharpoons Ag$	+0.80 V
	$Fe^{3+} + 1e^- \rightleftharpoons Fe^{2+}$	+0.77 V
	$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+0.34 V
	$2H^+ + 2e^- \rightleftharpoons H_2$	0.00 V
	$Fe^{3+} + 3e^- \rightleftharpoons Fe$	-0.04 V
	$Pb^{2+} + 2e^- \rightleftharpoons Pb$	-0.13 V
	$Fe^{2+} + 2e^- \rightleftharpoons Fe$	-0.44 V
↓ increasing strength as a reducing agent	$Zn^{2+} + 2e^- \rightleftharpoons Zn$	-0.76 V
	$Al^{3+} + 3e^- \rightleftharpoons Al$	-1.66 V
	$Mg^{2+} + 2e^- \rightleftharpoons Mg$	-2.36 V
	$Li^+ + 1e^- \rightleftharpoons Li$	-3.05 V

- A) A: 1 M $CuSO_4$ (aq) B: Cu C: 1 M $Fe(NO_3)_3$ (aq) D: Fe
- B) A: 1 M $CuSO_4$ (aq) B: Cu C: 1 M $FeSO_4$ (aq) D: Fe
- C) A: 1 M $AgCl$ (aq) B: Ag C: 1 M $FeSO_4$ (aq) D: Fe
- D) A: 1 M H_2SO_4 (aq) B: Cu C: 1 M $FeCl_2$ (aq) D: Graphite

20. The solubility product of $AgCl$ is given by:
 $K_{sp}(AgCl) = [Ag^+][Cl^-]$ Where $[Ag^+]$ and $[Cl^-]$ are the respective concentrations at equilibrium. A student added some solid $AgCl$ to deionized water. Which of the following will change the value of $K_{sp}(AgCl)$ of the system?



- A) Adding more $AgCl$ (s) to the mixture.
- B) Adding $NaCl$ (aq) to the mixture.
- C) Heating the mixture.
- D) Adding $AgNO_3$ (aq) to the mixture.

21. Capsaicin is a molecule that is found in most chillis. It interacts with the sensory receptors in our mouth and gives us the feeling of spiciness. The structural formula of a molecule of capsaicin ($C_{18}H_{27}NO_3$) is shown. Which of the following statements about capsaicin are true?



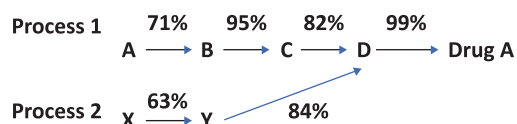
- Statement 1:** It decolourises bromine water in a dark room.
Statement 2: Upon reduction with $LiAlH_4$, $C_{18}H_{27}NO_2$ is formed.
Statement 3: Upon hydrolysis with HCl (aq), an amide and a carboxylate salt are produced.
Statement 4: It reacts with dilute carboxylic acids in an esterification reaction.

- A) 1 and 3 only B) 1 only C) 1, 2, and 4 only D) 2 and 3 only
22. John has a bottle of vinegar, which has a pH of around 2 to 3. Jeremy, who had a chemistry class earlier in the day on the topic of acids and bases, made the following comments, when he saw the vinegar:



- Statement 1:** "If you add a very large amount of water to the vinegar, the pH will increase."
Statement 2: "If you add a very large amount of water to the vinegar, the dissociation of acetic acid molecules will increase."
 Upon hearing these 2 statements, John said:
Statement 3: "Statement 1 is wrong. I agree that the dissociation of acetic acid molecules will increase, but pH should decrease."
 Which of the following statements are correct?

- A) 3 only B) 2 and 3 only C) 1 and 2 only D) 1 only
23. Drug A can be produced via two different synthesis methods, shown in the diagram below. The yields of each step of the two methods are shown as a percentage are also shown. While higher yield is an important consideration, the cost of the starting raw material required is also important. Calculate the overall yield of each process, and by considering both yield and cost of raw materials, determine which process would minimise the cost of production per unit of Drug A produced.



Raw material	Cost/mole
A	\$100
B	\$92

- A) The yields of each process are: Process 1, 54.8%; Process 2, 52.4%. The process that would minimize unit cost of production is Process 1.
 B) The yields of each process are: Process 1, 54.8%; Process 2, 52.4%. The process that would minimize unit cost of production is Process 2.
 C) The yields of each process are: Process 1, 52.4%; Process 2, 54.8%. The process that would minimize unit cost of production is Process 1.
 D) The yields of each process are: Process 1, 52.4%; Process 2, 54.8%. The process that would minimize unit cost of production is Process 2.

24. The ozone layer serves a critical function by shielding us from most of the harmful UV radiation from the Sun. In the late 20th century, it was recognized that certain chemicals used in refrigeration, air-conditioning and foam applications were responsible for the depletion of the ozone layer. This group of chemicals include hydrochlorofluorocarbons (HCFCs) and chlorofluorocarbons (CFCs). Which of the following statements about the depletion of the ozone layer caused by HCFCs and CFCs is false?



- A) Fluorine radicals react with ozone molecules
- B) UV radiation causes the lysis of the C-Cl bonds in the CFCs and HCFCs
- C) A by-product of the depletion process is oxygen gas
- D) ClO radicals are produced as intermediates in the mechanism

25. The metalloids are elements that have a wide range of applications in the modern economy, due to their importance in many technological devices.

METALLOIDS

1 H Hydrogen																	2 He Helium																												
3 Li Lithium	4 Be Beryllium											5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon																												
11 Na Sodium	12 Mg Magnesium											13 Al Aluminum	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon																												
19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton																												
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon																												
55 Cs Cesium	56 Ba Barium	57 La Lanthanum	72 Hf Hafnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon																												
87 Fr Francium	88 Ra Radium	89 Ac Actinium	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson																												
<table border="1"> <tr> <td>58 Ce Cerium</td> <td>59 Pr Praseodymium</td> <td>60 Nd Neodymium</td> <td>61 Pm Promethium</td> <td>62 Sm Samarium</td> <td>63 Eu Europium</td> <td>64 Gd Gadolinium</td> <td>65 Tb Terbium</td> <td>66 Dy Dysprosium</td> <td>67 Ho Holmium</td> <td>68 Er Erbium</td> <td>69 Tm Thulium</td> <td>70 Yb Ytterbium</td> <td>71 Lu Lutetium</td> </tr> <tr> <td>90 Th Thorium</td> <td>91 Pa Protactinium</td> <td>92 U Uranium</td> <td>93 Np Neptunium</td> <td>94 Pu Plutonium</td> <td>95 Am Americium</td> <td>96 Cm Curium</td> <td>97 Bk Berkelium</td> <td>98 Cf Californium</td> <td>99 Es Einsteinium</td> <td>100 Fm Fermium</td> <td>101 Md Mendelevium</td> <td>102 No Nobelium</td> <td>103 Lr Lawrencium</td> </tr> </table>																		58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium	90 Th Thorium	91 Pa Protactinium	92 U Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium
58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium																																
90 Th Thorium	91 Pa Protactinium	92 U Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium																																

For many of their properties, we can say that metalloids exhibit behaviour that is in-between that of metals and non-metals. For which of the following properties is this **not** correct?

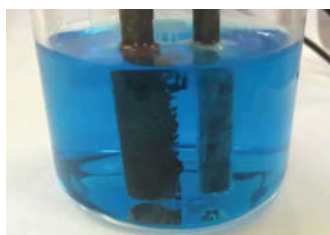
- A) Electronegativity
- B) Melting point
- C) Acidity of its oxides
- D) Electrical conductivity

26. In infrared spectroscopy, the sample to be tested is often sandwiched between slides made of an inorganic salt such as potassium chloride. This is because potassium chloride is transparent to infrared radiation, allowing the radiation to pass through the sample. A laboratory technician wants to clean his potassium chloride slides with a solvent, without the slides dissolving in the solvent. Which of the following solvents is most suitable?



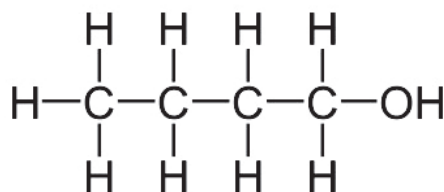
- A) Pure water
- B) Hexane
- C) A solution of 70% ethanol in water
- D) Dilute hydrochloric acid

27. A student wishes to perform electrolysis on an aqueous solution of copper (II) sulfate.



Which of the following combinations of electrodes will keep the concentration of copper ions in the solution constant throughout the duration of electrolysis?

- A) Cathode: Copper Anode: Graphite
 - B) Cathode: Copper Anode: Magnesium
 - C) Cathode: Graphite Anode: Graphite
 - D) Cathode: Graphite Anode: Copper
28. Butanol, a 4-carbon alcohol (butyl alcohol), is produced from the same feedstocks as ethanol, including corn grain and other biomass. However, butanol is superior to the more conventional ethanol in that butanol is immiscible in water, and has a higher energy content for the same volume. Furthermore, it is a better choice of fuel compared to more conventional fuels like gasoline as it is a renewable source of energy and there are fewer harmful emissions generated when ignited.



Above is the structure of butanol. Including the above structure, how many structural isomers of butanol contain hydroxyl groups?

- A) 5
- B) 3
- C) 2
- D) 4

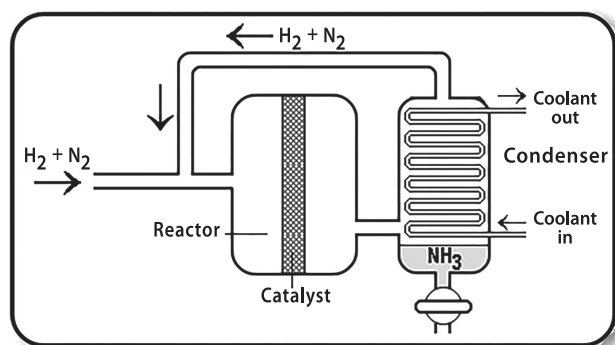
29. Polyethene, a versatile plastic, is a polymer resulting from the polymerisation of ethene monomers. Depending on its density, it can be classified as high-density Polyethene (HDPE) or low-density Polyethene (LDPE). HDPE is rigid and finds applications in water pipes, containers, and milk jugs, while LDPE's flexibility makes it suitable for plastic bags, films, and packaging. With its excellent properties, cost-effectiveness, and recyclability, polyethene is a key material in various industries, contributing to reduced waste and advancing sustainability efforts worldwide. Polyethene is a widely used plastic and has various applications in packaging, containers, plastic bags, films, toys, and many other products due to its flexibility, durability, and chemical resistance.



In the polymerisation of ethene to polyethene, which of the following quantities will not be changed?

- | | |
|----------------------|----------------------|
| A) Molecular formula | B) Density |
| C) Boiling point | D) Empirical formula |

30. The Haber process is a reaction utilized in industry to produce ammonia from nitrogen gas and hydrogen gas. $\text{H}_2 + \text{N}_2 \rightleftharpoons \text{NH}_3$



Usually, iron is used as a catalyst. Which of the following statements is not correct?

- A) Adding a catalyst lowers the activation energy of the Haber process.
- B) Adding a catalyst will increase the yield of the Haber process, when the system is allowed to reach equilibrium.
- C) Adding a catalyst increases the rate of the forward reaction in the Haber process.
- D) Iron is a heterogeneous catalyst in the Haber process.