

### ALL QUESTIONS WORTH 4 POINTS

1. In Korean cuisine, soups are often served in hot ceramic bowls. Hot soup at  $100^{\circ}\text{C}$  was poured into a hot ceramic bowl at  $200^{\circ}\text{C}$ . Which of the following statements is incorrect?

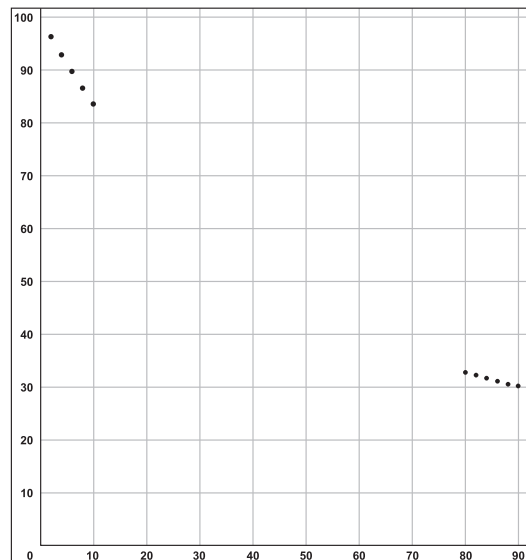


- A) The ceramic bowl loses heat to the soup and the surroundings.  
 B) There is insufficient information to calculate the temperature of the bowl and soup when they reach equilibrium with each other.  
 C) The soup is likely to boil.  
 D) Heat flows from the object with greater internal energy to the object with lower internal energy.
2. Luke is working in a company called StemH2O which makes water bottles. Luke wants to make a water bottle useful to store hot drinks in cold climates. Which of the following design features is not useful for the intended purpose?



- A) Painting the outside of the bottle with white glossy paint.  
 B) Having a large bottle opening.  
 C) Using a rubber material instead of metal to make the bottle cap.  
 D) Designing the bottle to have two walls with an air gap between the walls.

3. A student wanted to know how long it takes for a coffee mug to cool down from  $100^{\circ}\text{C}$  to a temperature of  $50^{\circ}\text{C}$ . He put a thermometer in his mug, started a stopwatch and began recording the temperature every 2 minutes. However, 10 minutes later, he was distracted and only returned 80 minutes from the beginning of the experiment. Measuring the change in temperature for another 10 minutes, the diagram shows the results of the temperature measurements ( $^{\circ}\text{C}$ ) over time (in minutes). Based on these data, what is the approximate time from the beginning of the experiment at the moment when the coffee temperature reached  $50^{\circ}\text{C}$ ?



- A) 72-74 mins      B) 16-18 mins      C) 64-68 mins      D) 46-48 mins

4. The specific latent heat of fusion  $L_f$  is the heat required to melt a unit of mass of a solid.  $Q = mL_f$  where  $Q$  denotes the heat required to melt the entire solid. An ice cube of mass  $8.00\text{ g}$  is left on a table, where it absorbs heat from the surroundings at a constant rate of  $15.0\text{ J/s}$ . Given that the specific latent heat of fusion of ice is  $334\text{ J/g}$ , how long does it take for the entire ice cube to melt?



- A)  $59\text{ s}$                       B)  $178\text{ s}$                       C)  $145\text{ s}$                       D)  $92\text{ s}$
5. Mouth pipetting was an experimental technique used in chemistry labs in the past. Nowadays, this is no longer done due to the risk of swallowing hazardous chemicals. Given the density of the pipetted solution is  $1.00\text{ g/ml}$ , and the height of liquid pipetted is  $5\text{ cm}$ , find the difference between the pressure inside the mouth of the chemist and atmospheric pressure. Take the gravitational field strength of the earth,  $g$ , to be  $9.81\text{ N/kg}$ .

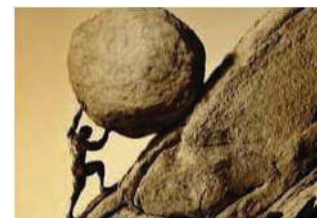


- A)  $491\text{ Pa}$                       B)  $522\text{ Pa}$                       C)  $489\text{ Pa}$                       D)  $434\text{ Pa}$
6. Your friend, Tim, notices that when he cooks instant noodles, there is less water in the pot after he finishes boiling it. He decides to conduct an experiment to look at the behavior of water. He sets up two identical beakers, each with  $200\text{ ml}$  of water. In Beaker A, he places hot, boiling water and keeps it boiling, while in the Beaker B, he places water at  $80\text{ degrees celsius}$ . After  $10\text{ mins}$ , he goes back to look at the amount of water left in each beaker. Which statement is correct?



- A) Only beaker B has a decreased water level.  
 B) Both water levels have dropped, with beaker B having less water.  
 C) Only beaker A has a decreased water level.  
 D) Both water levels have dropped, with beaker A having less water.

7. In the olden Greek myth, Sisyphus, a Greek king, was punished by Hades and made to roll a stone ball up a hill for all eternity. Ordinarily, Sisyphus exerts  $1000\text{ N}$  of force on the ball to keep it moving at a constant speed. One day, while rolling the ball up the hill, Sisyphus suddenly starts exerting  $1500\text{ N}$  of force on the ball. Air resistance is significant in this question. How will the movement of the ball change when Sisyphus increases his force from  $1000\text{ N}$  to  $1500\text{ N}$ ?

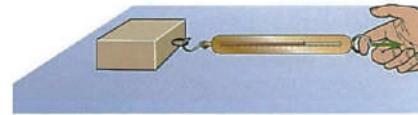


- A) The ball will roll faster for some time but then slowly decelerate to its original speed.  
 B) The ball will keep rolling up faster and faster without reaching a constant speed.  
 C) The ball will not roll any faster and will continue at a constant speed.  
 D) The ball will start rolling up faster, and eventually reach a constant speed higher than what it was previously.

8. Roast duck is a Cantonese delicacy that can be found in China and in areas with Chinese communities. The high heat of the charcoal-fired oven gives the skin a nice golden brown colour and a crispy texture, as the marinade on the skin is caramelized by the strong heat. Although the skin is roasted with the high heat, the meat inside is not burnt. Which statement best explains this phenomenon?



- A) The duck skin is a good reflector of heat  
 B) The duck meat is a poor radiator of heat  
 C) The duck meat is a poor conductor of heat  
 D) The air in the oven takes heat away by convection
9. Static friction and kinetic friction are forces that act to resist motion. When one object moves across another object, the force that must be applied to begin moving is known as static friction. Once the object is in motion, the force that resists its motion is known as kinetic friction. Bob set up an experiment to determine if the surface area of blocks affects the static friction and kinetic friction. He obtained 4 wooden blocks, made of the same material and having the same mass, but with different shapes. He attached a force meter to each of them and dragged them along the table. His results are shown below:



Surface area in contact with the table/cm <sup>2</sup>	Static Friction /N	Kinetic Friction /N
10	0.92	0.56
15	0.95	0.56
20	0.93	0.59
30	0.94	0.55

What is the effect of contact surface area on static friction and kinetic friction?

- A) Contact surface area affects kinetic friction but not static friction.  
 B) Contact surface area affects both static friction nor kinetic friction.  
 C) Contact surface area affects static friction but not kinetic friction.  
 D) Contact surface area affects neither static friction nor kinetic friction.
10. Most cars require petrol to move. Hot gases produced by burning petrol in the engine pushes pistons in the engine, which generate force to turn the wheels. In recent years, electric cars are getting more popular, as they completely do not rely on fossil fuels like petrol. Instead, batteries on the car power an electric motor, which turns the wheels of the car. These cars are more environmentally-friendly, if renewable energy is used to charge the battery. What form of energy conversion occurs when driving an electric car?
- A) Heat energy → Kinetic energy  
 B) Chemical potential energy → Kinetic energy  
 C) Chemical potential energy → Electrical energy → Kinetic energy  
 D) Chemical potential energy → Heat energy

11. Cup Noodle is a brand of instant noodles that can be prepared at any time, as long as heated water is added into the cup. James wanted to make cup noodles for himself. However, he did not prepare the cup noodles correctly, and the packaging burst open! Which of the following reasons would explain why the packaging burst?



- A) He added cold water instead of hot water.  
 B) The plastic melted after hot water was added.  
 C) He did not open the air-tight packaging and heated the cup directly.  
 D) He placed a lid over the cup after adding hot water.
12. Jack was learning how to use a microscope in the laboratory. The microscope has different lenses, each of which have different magnifications. Jack examines a cell on a microscope slide. Using the lens with 1000x magnification, the cell appears to be 5 mm in diameter. Jack then switches to the lens with 3000x magnification. He also adds a piece of glass to the slide that has a magnification of 2.5x. How large will the cell appear to be?

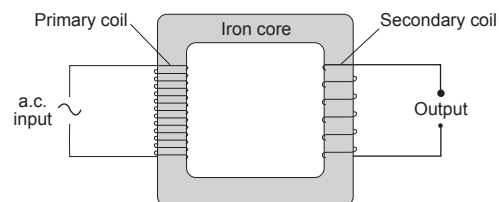


- A) 3.75 cm                      B) 37.5 cm                      C) 3 mm                      D) 5 cm
13. The Vogel Rok is a roller coaster in the Efteling amusement park, located in Kaatsheuvel, Netherlands. The maximum G-force that a person experiences on the ride is 3.5. The G-force describes the forces experienced by a person as a ratio of the gravitational force per unit mass due to the Earth. It can be calculated by dividing a force (in newtons) by 9.81. Which of the following statement is incorrect?



- A) At the peak G-force, it is harder for a person to lift their arm in the direction opposite of the force.  
 B) If a rider is standing on a weighing scale in the roller coaster, the reading will be multiplied by 3.5x at the peak G-force.  
 C) The mass of a rider in the roller coaster is multiplied by 3.5x at the peak G-force.  
 D) When the roller coaster is not moving, the rider experiences a G-force of 1.

14. While Transformers is a name usually used to refer to the shapeshifting Autobots and Decepticons fighting for their race and planet Earth, it is also used to refer to a set-up in the world of electricity that controls voltage. A drawing of a transformer is shown. Using the ratio of turns between the primary coil and secondary coil, a transformer is able to convert the input into a larger or lower voltage output. The formula is shown below, with  $N$  being number of turns and  $V$  being voltage.  $p$  represents the primary coil, while  $s$  represents the secondary coil.



$$\frac{N_p}{N_s} = \frac{V_p}{V_s}$$



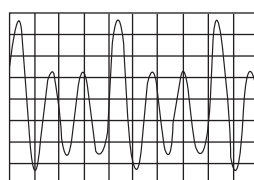
In the diagram, the primary coil has 50 turns and an input voltage of 100kV. How many turns should the secondary coil have to produce an output voltage of 20kV?

- A) 25 turns                      B) 5 turns                      C) 250 turns                      D) 10 turns

15. A musician wants to test out his new instruments, a guitar and a flute, in order to find out the maximum pitch of each instrument and how loud they can be (Pitch = Frequency). Having no access to a proper recording studio, the musician consults his friend, who runs a physics lab, to help him test these two qualities of the instruments. The musician's friend brings out a cathode-ray oscilloscope and he starts playing his instruments.



flute



guitar

These are the results from the cathode-ray oscilloscope. What can we conclude about the maximum loudness and pitch of the instruments?

- A) Only the maximum loudness is the same.  
 B) Only the pitch is the same.  
 C) The maximum loudness and the pitch are the same.  
 D) Both the maximum loudness and pitch are different.
16. Liquefied natural gas (LNG) is an important energy commodity in the world we live in today. Natural gas, which mainly consists of methane, can be combusted to produce heat and thus, it is burnt for heating and electricity generation. However, the transportation of gaseous natural gas across the world's oceans would be too inefficient and would not be economically viable. The capacity of a particular LNG carrier is 100,000 m<sup>3</sup>. Assuming that the density of LNG is 500 kg/m<sup>3</sup> and that natural gas behaves ideally at r.t.p., the maximum volume of natural gas (measured at r.t.p.) that can be transported by the LNG carrier is determined to be xm<sup>3</sup>. Determine the value of x/100,000.



You may find the following data useful:

Molar volume of an ideal gas at r.t.p. = 24 dm<sup>3</sup> Molar mass of methane = 16 g

- A) 7500                      B) 750                      C) 750,000                      D) 75,000

17. Fire was one of the biggest contributors towards the development of modern human society. Even before humans learnt of science and technology, the discovery of fire was a huge stepping stone in mankind's progress towards civilization. However, it may surprise you to learn that the burning of objects is also a chemical reaction; it is an energy-releasing reaction known as combustion. During a combustion reaction, oxygen and fuel (the burning object) are consumed, and the products of the reaction tend to be oxidised. Combustion can be incomplete when there is not enough oxygen for the combustion reaction to occur fully, and this may result in different products being formed. Which of the following cannot be a product of a combustion reaction?



- A) CO                      B) H<sub>2</sub>O                      C) O<sub>2</sub>                      D) CO<sub>2</sub>

18. Humans have been grilling fish for ten thousand years. Ten thousand years later, Bob went to eat grilled fish. When grilling, fish meat is observed to turn from translucent to white. Which statement best explains the change that the fish meat undergoes when being grilled?



- A) It is a change in physical state, since heating is involved.  
 B) It involves a chemical change, as the fish meat cannot be changed back to the translucent state even upon cooling.  
 C) It is a change in physical state, as the fish meat cannot be changed back to the translucent state even upon cooling.  
 D) It involves a chemical change, as the fish meat can be changed back to the translucent state upon cooling.

19. In chemistry, the study of energy changes is known as Energetics, and it is an important area of physical chemistry that has a wide range of implications on the chemical processes that are vital to our modern economy. Which of the following is not necessarily correct for a reaction that releases more heat energy than it absorbs?

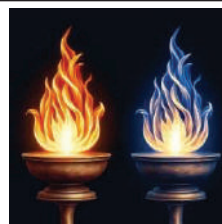


- A) The products have a lower energy than the reactants.  
 B) The reaction is an exothermic reaction.  
 C) The sign of enthalpy change is negative.  
 D) This reaction can occur rapidly at all temperatures.

20. Hydrogen peroxide can act as both an oxidizing agent and a reducing agent. It can be found in some shops as a disinfectant, and its redox activity is a reason for its antimicrobial properties. In which reaction is H<sub>2</sub>O<sub>2</sub> acting as a reducing agent?

- A) H<sub>2</sub>O<sub>2</sub> (aq) reacting with FeCl<sub>2</sub> (aq) to produce FeCl<sub>3</sub> (aq) and H<sub>2</sub>O (l)  
 B) H<sub>2</sub>O<sub>2</sub> (aq) reacting with KI (aq) to produce KOH (aq) and I<sub>2</sub> (aq)  
 C) H<sub>2</sub>O<sub>2</sub> (aq) reacting with KMnO<sub>4</sub> (aq) to produce MnO<sub>2</sub> (s) and O<sub>2</sub> (g)  
 D) H<sub>2</sub>O<sub>2</sub> (aq) reacting with SO<sub>2</sub> (aq) to produce H<sub>2</sub>SO<sub>4</sub> (aq)

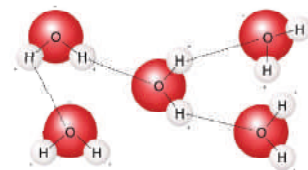
21. Generally, there are two types of bunsen flame: non-luminous flame and luminous flame. The non-luminous flame is preferred for most heating done in the Chemistry Lab. Which of the following statements about the non-luminous flame is false?



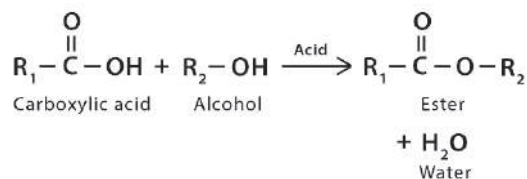
- A) It can be used to heat a substance strongly.  
 B) It attains a higher temperature than the luminous flame.  
 C) It is a steady bluish flame.  
 D) It produces more soot than the luminous flame.
22. Litmus paper is a useful tool for experimental chemists to quickly check whether a substance is acidic or basic. Blue litmus paper shows the presence of acids by turning red, and red litmus paper shows the presence of bases by turning blue. Which of the following compounds will not cause any change to a strip of blue litmus paper?



- A) Vinegar  
 B) Hydrochloric acid  
 C) Ammonia solution  
 D) Lemon juice
23. The isolated proton does not exist in solution. Due to its high charge density, it will most definitely interact with surrounding water molecules to form the hydronium ion ( $\text{H}_3\text{O}^+$ ). Even the hydronium ion will interact strongly with more water molecules to form clusters. Which of the following is not a possible formula for the cluster formed from the interaction of a single hydronium ion with surrounding  $\text{H}_2\text{O}$  molecules?



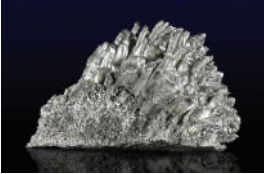

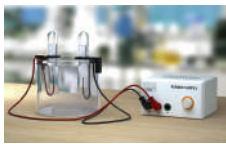


- A)  $\text{H}_{15}\text{O}_7^+$   
 B)  $\text{H}_{43}\text{O}_{21}^+$   
 C)  $\text{H}_7\text{O}_3^+$   
 D)  $\text{H}_{21}\text{O}_{11}^+$
24. Esterification involves the reaction of a carboxylic acid and an alcohol to form an ester, a compound with the  $\text{RCOOR}$  structure. A schematic for the esterification reaction is shown below.  $\text{R}_1$  and  $\text{R}_2$  generically refer to the rest of the carboxylic acid and alcohol molecules respectively.



A carboxylic acid of the formula  $\text{C}_4\text{H}_8\text{O}_2$  reacts with an alcohol of the formula  $\text{C}_5\text{H}_{10}\text{O}$ . What is the formula of the resultant ester?

- A)  $\text{C}_9\text{H}_{16}\text{O}_3$   
 B)  $\text{C}_9\text{H}_{18}\text{O}_3$   
 C)  $\text{C}_9\text{H}_{16}\text{O}_2$   
 D)  $\text{C}_9\text{H}_{14}\text{O}_2$
25. A chemist is investigating the decomposition of an aqueous solution of hydrogen peroxide catalyzed by an enzyme extracted from chicken liver. The rate of the reaction is monitored by the rate of the production of oxygen gas, a product of the decomposition reaction. Which of the following will increase the rate of the production of oxygen?



- A) Adding more hydrogen peroxide solution of the same concentration.  
 B) Increasing the concentration of the enzyme catalyst.  
 C) Heating the reaction mixture to 80 degrees Celsius.  
 D) Using a larger vessel for the reaction.
26. Magnesium is best known for burning with a characteristic brilliant white light. The metal itself was first produced by Sir Humphry Davy in 1808 by the electrolysis of magnesia, which is magnesium oxide. During the electrolysis, inert electrodes were used. What is the ionic equation for the product formed at the cathode?
- 
- A)  $Mg^{2+} + 2e^{-} \rightarrow Mg$     B)  $Mg^{+} + e^{-} \rightarrow Mg$     C)  $2O^{2-} \rightarrow O_2 + 4e^{-}$     D)  $O^{2-} \rightarrow O_2 + 2e^{-}$
27. In a redox reaction, exchange of electrons occur. Metals and their oxides participate in redox reactions; a metal can be oxidized to form its oxide, and the oxide can be reduced to form the metal. Which of the following pairs of a metal and a metal oxide can undergo a redox reaction when heated?
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- A) Al and  $Fe_2O_3$     B) ZnO and Fe    C) MgO and Fe    D) Cu and  $Fe_2O_3$
28. The hydrolysis of aqueous NaCl can produce different products at the electrodes, depending on the concentration of NaCl in the solution. Which of the following is least likely to be produced during the hydrolysis of an aqueous solution of NaCl?
- 
- A) Chlorine gas    B) Sodium metal    C) Hydrogen gas    D) Oxygen gas
29. A solid X contains two substances. When solid X was added to aqueous sodium chloride, it dissolved to form a clear colorless solution. When solid X was added to hydrochloric acid, effervescence was observed. Which of the following could be the two substances in X?
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- A) Sodium carbonate and magnesium metal  
 B) Sodium carbonate and lead (II) chloride  
 C) Magnesium chloride and aluminium chloride  
 D) Sodium carbonate and magnesium chloride
30. Joel collected three metal cubes, labelled as X, Y and Z. He notes the following observations.  
 Excess metal Z is dissolved in dilute hydrochloric acid. When metal X is placed in the resultant solution, it is able to displace metal Z out of the solution. Of the three metals, only metal Y reacts with water at room temperature to form a solution which turns red litmus paper blue.  
 What is the sequence of metals ordered in decreasing reactivity?
- 
- A) Y,Z,X    B) X,Y,Z    C) X,Z,Y    D) Y,X,Z