**Chemistry exam June 2010 QEP Marking Key**

**Section 1 – Oxygen Daytrip**

|  |  |
| --- | --- |
| **Theme:** Gases  **Concepts and processes** |  |
| * Physical properties of gases * Kinetic theory of gases | * Ideal Gas Law |

**A. Example of an appropriate solution**

**QUESTION 1.1**

*Daytrip 1*

Total length of tour

3 hours + 1 hour 45 min + 1 hour 45 min

3 hours × 60 min/hour + 1 hour × 60 min/hour + 45 min + 1 hour × 60 min/hour + 45 min = 390 min

Since Samuel needs 1 L/min of O2, this makes 390 L of oxygen needed at atmospheric pressure.

How many litres can he get from the tank?

Volume of tank (*V*1) = 3.0 L

Maximum pressure (*P*1) = 1.38 x 104 kPa

Atmospheric pressure (*P*2) = 101.3 kPa



Therefore there is enough O2 for this daytrip.

Is the tank too heavy?

Mass of tank: 9.25 kg empty.

What about the mass of the gas?





17 moles O2 × 32 g/mole = 5.4 × 102 g

O2 gas = 0.54 kg

9.25 kg + 0.54 kg = 9.79 kg < 10 kg

Therefore he would be permitted to take this luggage for this daytrip.

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*Daytrip 2*

Total length of tour: 2.5 hours + 0.50 hours + 0.50 hours = 3.5 hours

3.5 hours × 60 minutes/hour = 210 minutes

Since Samuel needs 2.0 L/minute of oxygen, 210 minutes \* 2 L/min = 420 L required.

It was determined that the tank provides 4.1 × 102 L < 420 L Therefore there is not enough O2 for daytrip.

There is no mass limit, so this is irrelevant.

*Conclusion*

*Daytrip 1:*

Samuel will/will not have enough oxygen to last through this daytrip.

His oxygen tank will/will not exceed the maximum mass limit for this daytrip.

*Daytrip 2:*

Samuel will/will not have enough oxygen to last through this daytrip.

His oxygen tank will/will not exceed the maximum mass limit for this daytrip.

Samuel should choose daytrip \_\_\_\_1\_\_\_\_\_

**QUESTION 1.2**

\* Students were asked to identify and explain two precautions. Below are three possible precautions. If students include all three, then an increase in level (competency) would be appropriate.

*Precaution 1 – Do not puncture*

According to the kinetic molecular theory, molecules of gas move in a straight line until they hit something. In the oxygen tank, the pressure is very high which means that there are a very large quantity of molecules moving around and hitting each other and the walls of the tank. If the tank is punctured, then the molecules which would have hit that point in the tank will escape the tank instead. Since the pressure is so high, many gas molecules will do this at once. The force of so many molecules of gas leaving the same place at once can result in a dangerous explosion.

*(The following explanation goes above and beyond the expected answer. This would be a reason to increase their grade level.)*

As well, since all actions are accompanied by a reaction, unless the oxygen tank is tied down VERY well, as the gas molecules rush out they will send the gas tank in the opposite direction turning it into a dangerous projectile. This can lead to property damage or death.

*Precaution 2 – Do not expose to high temperatures*

According to the kinetic molecular theory of gases, as temperature goes up, the kinetic energy of gas molecules increases (the molecules move faster). Thus, if the oxygen tank is exposed to excessive heat or an open flame, the molecules of gas inside will move much faster. This leads to more gas molecules hitting the wall of the oxygen tank at one time which results in increased pressure inside the tank. If the pressure in the tank goes above the maximum pressure indicated, the tank could explode.

Note: alternative answers could mention Charles' law: as the temperature increases the gas molecules need to take up more space and since volume can't increase pressure does instead according to Boyle's law, leading to the same conclusion.

*Precaution 3 – Do not place near open flame*

Same explanation as above. Also, if the oxygen is exposed to a flame, the likelihood of combustion would be greater. (Fire Triangle))

**Section 2 – Brr … cold! Ouch … hot!**

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| --- | --- |
| **Theme:** Thermodynamics  **Concepts and processes** |  |
| * Energy diagram * Activation energy | * Enthalpy change * Molar heat of reaction |

**A. Example of an appropriate solution**

**NaCl**

ΔH = +3.9 kJ/mol

Enthalpy

(kJ/mol)

20

80

Reaction Progress

0

40

60

(Student must include an endothermic graph with activation energy and ΔH of +3.9 kJ)

Endothermic Reaction: The temperature of the solution decreases. The ΔH is positive, therefore the reaction is endothermic. The NaCl absorbs energy from the water, thus decreasing the temperature of the solution.

**CaCl2**

|  |  |
| --- | --- |
|  | -*Q*loss = *Q*gained  Qloss = -*Q*gained  *Q*loss = -5.97 kJ  (5.97 kJ was released or ‑5.97 kJ) |
|  |  |

Enthalpy

(kJ/mol)

30

120

Reaction Progress

0

60

90

(Student must include an exothermic graph with an activation energy and a ΔHof ‑82.9 kJ/mol)

Exothermic Reaction: The reaction is exothermic since the ΔH is negative. CaCl2 releases energy thus increasing the temperature of the solution.

**NH4NO3**

The first three given equations remain the same. The ΔH of the fourth equation is reversed.

ΔHsol = (-81.17 kJ/mol) + (-206.0 kJ/mol) + (-52.6 kJ/mol) + (+365.6 kJ/mol)

ΔHsol = 25.8 kJ/mol

Enthalpy

(kJ/mol)

30

120

Reaction Progress

0

60

90

(Student must include an endothermic graph with an activation energy and a ΔHof 25.8 kJ/mol)

Endothermic Reaction: The reaction is endothermic since the ΔH is positive. NH4NO3 absorbs energy from the water thus decreasing the temperature of the solution

**POSSIBLE TABLE**

Table 1: Salts

|  |  |  |  |
| --- | --- | --- | --- |
| **Salt** | **ΔHsol (kJ/mol)** | **Exothermic or endothermic** | **Effect on temperature of solution (increase or decrease** |
| NaCl | +3.9 | Endothermic | Decrease |
| CaCl2 | -82.9 | Exothermic | Increase |
| NH4NO3 | +25.8 | Endothermic | Decrease |

**RECOMMENDATION**

CaCl2 is the only salt suitable for a hot pack because it is the only salt that produces an exothermic reaction, thus causing the solution to heat up. NH4NO3 is the best choice for a cold pack because it produces an endothermic reaction, absorbing heat from the water and cooling down the solution. Although NaCl gives an endothermic reaction, it is not suitable as a cold pack since its ΔHsol value is low, meaning the temperature of the solution will not cool down very much.

**Section 3 – Healthy Heart**

|  |  |
| --- | --- |
| **Theme:** Rates of Reaction  **Concepts and processes** |  |
| * Factors that influence reaction rate * Concentration * Temperature * Catalysts | * Rate Law |

**A. Example of an appropriate solution**

**QUESTION 3.1A**

The rate law equation for the reaction is: rate = k [NO]2 [O2]



The rate constant k = 25 mol/L • s

rate = k [NO]2 [O2]

rate = (25 mol/L • s)(0.015 mol/L)2 (0.0050 mol/L)

rate = 2.8 × 10-5 mol/L • s

**The rate of reaction is: 2.8 × 10-5 mol/L • s**

**QUESTION 3.1B**

O2 reacting



NO2 forming



**The rate at which O2 is reacting: 5.0 × 10-5 mol/L • s**

**The rate at which NO2 is forming: 1.0 × 10-4 mol/L • s**

**QUESTION 3.2A**

The rate law equation for this reaction is rate = k[NO]2 [O2]. Since there are fewer molecules when the concentration of O2 is halved, then there will be fewer collisions therefore slowing down the rate of formation of NO2. The rate decreases by half when the concentration of O2 is decreased in half.

**QUESTION 3.2B**

When the temperature is increased, this increases the kinetic energy of the molecules, therefore causing more frequent and effective collisions which then increases the rate of formation of NO2.

**QUESTION 3.3A**

Graph 1

Individual 1

Individual 2

Volume of

NO (g)

collected

(mL)

time (s)

0

2

4

10

20

30

40

1

3

Justification:

Individual 1 is the individual who would have taken the arginine pill since the volume of NO(g) collected is increasing much faster than in individual (as seen in line 2). Therefore the reaction rate for individual 1 is faster.

**QUESTION 3.3B**

*Below are two graphs with all the proper information. Students may choose to provide only one graph with all pertinent information. Both are equally correct.*



Justification:

The activation energy is lower in diagram 2, which represents the reaction with the catalyst or arginine pill. The catalyst provides a reaction pathway with a lower activation energy which makes collisions more likely to be effective therefore the arginine pill increases the reaction rate.

**Section 4 – Doctor Patient Confidentiality**

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| --- | --- |
| **Theme:** Chemical Equilibrium  **Concepts and processes** |  |
| * Factors that influence the state of equilibrium * Concentration * Le Chatelier’s Principle | * Equilibrium constant * Solubility-product constant * Relationship between pH and the molar concentration of hydronium and hydroxide ions |

**A. Example of an appropriate solution**

**QUESTION 4.1**

Initial pH of the stomach



pH of the stomach after food has entered



Factor: 

**The hydrogen ion concentration increases by a factor of 1.3 × 102.**

**QUESTION 4.2**

Step 1



Step 2



Step 3



Step 4



**The Milk of Magnesia will help to neutralize the acid in the stomach since it is basic (pH 10.350).**

**QUESTION 4.3**

The use of bicarbonate based antacids will increase the  and cause the equilibrium to shift to the left. As a result the reverse reaction would be favored and the [H+] would decrease. A decrease in [H+] causes the pH to increase. An increase in the pH of the blood is called Alkalosis.

**QUESTION 4.4**

The greater the equilibrium constant the more likely the forward reaction is to occur.

Since the equilibrium constant is 200 times greater for the reaction with CO and hemoglobin than O2 and haemoglobin, the hemoglobin will be 200 times more likely to bind with a CO molecule than an O2 molecule if both are available.

Therefore when a small amount of CO is present, the hemogoblin will bind to it in preference to O2.

As a result the body will not get the O2 it requires and the body will suffer oxygen deprivation and possibly death.

**Section 5 – So What Do You Think?**

A multitude of answers can be found in this section. The key elements that need to be included in this response are as follows:

1. The student must choose a minimum of two of the four sections of the Chemistry program to defend.
2. Each of the two chosen sections must include three sound arguments for why each section is to be kept in the chemistry program
3. Each of the two chosen sections must have several every day, real-life examples that explain the chemistry-phenomenon they are defending.
4. The scientific language and terminology must be correct and appropriate.
5. The message must be adapted to the target audience (governing board).
6. The information must be organized in a way that makes it easier for the reader to understand.
7. Any other elements that have been discussed in class and worked on throughout the year with respect to the delivery of scientific messages should be part and parcel of the evaluation of this question.