BioMedical Admissions Test (BMAT)

Section 2: Chemistry

Questions by Topic

C11 - Energetics

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(Mark Scheme and explanations at the end)

1 Which of the following will definitely be an endothermic reaction?

A $CaCO_3 \rightarrow CaO + CO_2$
B $HCl + NaOH \rightarrow NaCl + H_2O$
C $H_2SO_4 + CaO \rightarrow CaSO_4 + H_2O$
D $2\ Fe + O_2 \rightarrow 2FeO$
E $CH_4 + 2O_2 \rightarrow 2CO_2 + 2H_2O$

2 Here are five potential errors in a calorimetry practical.

Which of the following statements would lead to a higher value of energy transferred being measured?

1 Adding more water than recorded into the calorimeter.
2 Recording an initial temperature which is $2^{O}C$ below the true value.
3 Spilling some fuel from the spirit burner before finding the final mass reading for it.
4 Mistakenly using a fluid with a lower specific heat capacity than water.

A 1 and 2 only
B 2 and 3 only
C 2 and 4 only
D 1, 2 and 4 only
E None of the statements

3 100g of water is heated by 25^{O}C.

If 4 moles of a fuel were used, what is the value of energy transferred in total? And what was the energy change per mole of fuel burned?

[Specific Heat capacity of Water is 4.2J/g/ ^{O}C; Q = MC Δ T]

	Total energy transferred	**Energy transferred per mole**
A	10500	2625
B	2500	625
C	10500	42000
D	2500	10000

4 Which of the following does not decrease the energy loss of the calorimetry reaction?

A Using a lid on the cup.
B Using a metal cup.
C Placing the cup into a beaker of cotton wool.
D All of the above.
E None of the above

5 The specific heat capacity of water is 4.2J/g/ ^{O}C.

When heated with 42KJ of energy, by how many degrees would 1kg of water be heated?

A 0.1^{O} C
B 1^{O} C
C 10^{O} C
D 100^{O} C
E 1000^{O} C

6 Nitrogen and hydrogen can be combined to form ammonia gas, NH_3.

Using the bond energy values given below, determine the energy change of this reaction, ΔH.

$N \equiv N$	N - H	H - H
942kJ/mol	386kJ/mol	432kJ/mol

A - 32 kJ/mol
B 32 kJ/mol
C 22 kJ/mol
D 78 kJ/mol
E - 78 kJ/mol

7 A reaction occurs between sodium hydroxide and hot, concentrated chlorine gas. The products are sodium chloride, sodium chlorate ($NaClO_3$) and water, all of which are colourless. The temperature of the reaction was measured at 57.3 degrees C at the start of the reaction, and 93.2 degrees C at the end.

What effect will **separately** increasing the temperature and **then** increasing the pressure have on the reaction mixture?

A Reaction mixture turns brown on increasing temperature, no change on increasing pressure.
B Reaction mixture turns brown on increasing temperature, turns colourless on increasing pressure.
C Reaction mixture turns yellow-green on increasing temperature, no change on increasing pressure.
D Reaction mixture turns yellow-green on increasing temperature, turns colourless on increasing pressure.
E Reaction mixture turns red on increasing temperature, turns colourless on increasing pressure.

8 Hydrated copper sulfate ($CuSO_4.5H_2O$) is placed in a heated beaker. After 15 minutes, the colour of the compound has changed from blue to white.

Which statement below best explains this process?

A Water that was chemically bonded to a giant ionic lattice has left the structure.

B Water that was held within the $CuSO_4$ by weak intermolecular forces has left the structure.

C Water that was held within the $CuSO_4$ separately as hydrogen and oxygen atoms has left the structure.

D Water that the $CuSO_4$ was dissolved in has left the structure.

E Water vapour in the air surrounding the $CuSO_4$ molecules has left the structure.

Answers and Explanations

1 **A is the answer.**

Equation A shows a thermal decomposition reaction which is therefore always endothermic.

B is incorrect because it is a type of neutralisation reaction which are always exothermic.
C isn't right because again it is a neutralisation reaction as CaO is basic.
D is an oxidation reaction (as it has gained oxygen) and these are exothermic.
E is incorrect because all combustion reactions are exothermic.

2 **C is the answer.**

Statements 2 and 4 are the only correct answers.

In all of these, it is important to remember the calorimetry equation $Q = MC\Delta T$ which is:

Energy transferred (J) = Mass of water (g) x Specific heat capacity of water x Temperature change (^{O}C)

Statement 1 is incorrect because this would decrease the temperature change as there are more molecules to heat and so the calculated value for energy transferred will be low.
Statement 2 is correct because this would lead to an error in which the temperature change is 2 ^{O}C higher than in reality, increasing the Q value found.
Statement 3 is incorrect because this is not involved in the $Q = MC\Delta T$ equation. It would also decrease the value calculated if the next step is to calculate energy change per mole of fuel burned.
Statement 4 is correct. This would lead to a higher change in temperature as each molecule needs less energy to increase by 1^{O}C and so the temperature change would increase with no decrease in specific heat capacity and so, given $Q = MC\Delta T$, the value for Q would be higher.

3 **A is the answer**

This has both the correct specific heat capacity and calculation for energy transferred per mole.

B is incorrect – this has failed to multiply by 4.2 for the specific heat capacity.
C is incorrect – this has multiplied by 4 moles rather than dividing by 4 to find the value for energy transferred per mole.
D is incorrect – this has both failed to multiply by 4.2 for the specific heat capacity and then multiplied by 4 moles rather than divided.

4 **B is the answer**

This is because a metal cup is a conductor and so would increase energy loss. Instead, a polystyrene cup is most commonly used.

A is incorrect because it reduces heat loss by evaporation.
C is incorrect because this increases the thermal insulation of the experiment.

5 **C is the answer**

This is because when the steps below are followed, the energy transferred is sufficient for $10\,^{O}C$ change in water temperature.

1. First get all the numbers into the correct format for the equation.
   1kg of water is 1000g and 42KJ is 42000J.

2. Next find the amount of energy for $1\,^{O}C$ temperature change in 1kg of water. This is 4.2 x 1000 = 4200 $J/^{O}C$

3. 42000/4200 gives 10 so there will be a $10\,^{O}C$ temperature change – answer C.

6 **The answer is E**

The final equation is $N_2 + 3H_2 \rightarrow 2NH_3$.
The bonds broken are 1 N=N and 3 H-H = 942 + 1296 = 2238 kJ.
The bonds created are 6 N-H = 6 * 386 = 2316 kJ.
2238 - 2316 = **-78 kJ/mol**.
This is a negative value, hence the reaction is exothermic. Another way to think about this is that the energy of the bonds created was greater than that of the bonds broken, meaning that the reaction gave out energy (was exothermic).

7 **The answer is C**

The balanced reaction is:
$6NaOH + 3Cl_2 \rightarrow 3H_2O + 5NaCl + NaClO_3$
As the equation has 9 moles on both sides the change in pressure would not shift the equilibrium to either side so no change would occur. (An increase in pressure will shift the equilibrium to the side with fewer moles.)
As the reaction temperature increases from 57.3 degrees to 93.2 degrees throughout the reaction, this tells us the reaction is exothermic. So an increase in temperature would shift the reaction to the left hand side to oppose this increase. The Cl_2 would make the solution a green/yellow colour.

8 **The answer is A**

The copper sulfate forms a giant ionic lattice, to which water molecules are chemically bonded. On heating, these water molecules are broken from the lattice, instigating a colour change from blue to white.