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Unit 4 Chemistry

Practice Exam Solutions

Stop!

Don't look at these solutions until you have attempted the exam.

Found a mistake?

Check the Engage Education website for updated solutions, and then email practiceexams@ee.org.au.

Section A – Multiple-choice questions

Question 1

The correct answer is B. That is the correct way of expressing equilibrium constants

Question 2

The correct answer is C. A catalyst decreases the activation energy of a reaction.

Question 3

The correct answer is B. The activation energy of the reverse, exothermic reaction is the activation energy of the forward reaction minus ΔH. In this case it is 300 – 260 = 40kJ/mol

Question 4

The correct answer is A. The reverse reaction is exothermic, so a negative sign is ascribed to the ΔH (260kJ) because energy is lost in the reaction.

Question 5

The correct answer is A. The first step in figuring out this solution is to note that line one sharply increases, indicating a reactant has been added. The fact that the two other lines change in the same way suggests that they are on the same side of the arrow, so we can deduce that it was reactant reactant Y that was added.

Question 6

The correct answer is B. Electrons are pumped into the cathode of an electrolytic cell, causing it to be negative and polarity and reduction to occur

Question 7

The correct answer is B. The calculation is as follows: 889kJ/mol x 1.64 x 10^{-2} / 2.00 = 7.29kJ/^{o}C

Question 8

The correct answer is C. When a solution is diluted, the concentrations off all reactants and products decrease, regardless of whether or not it is an equilibrium reaction.

Question 9

The correct answer is D. The pOH of lithium hydroxide, a strong base, is determined by $-\log_{10}([OH^-])$ and is 1.15. To find the pH, the pOH must be subtracted from 14 (at 25^{o}C). Thus, the pH is 14-1.15 = 12.85

Question 10

The correct answer is B. Students must refer to the electrochemical series in the data booklet to answer this question.

Question 11

The correct answer is B. When the temperature of an equilibrium system is raised, not every particle will increase in kinetic energy to the same extent, but the average kinetic energy of the system is increased

Question 12

The correct answer is A. Australia has large coal reserves.

Question 13

The correct answer is B. Black coal is found lower in the earth than brown coal, which is found below peat.

Question 14

The correct answer is A. The Latrobe valley has large deposits of brown coal. If students did not know this answer, knowing the correct response to question 12 would have been useful in guessing.

Question 15

The correct answer is B. Fuel cells do not run flat because the reactants are continuously being supplied and products continuously removed

Question 16

The correct answer is A. In electrolysis, oxidation occurs at the positive electrode and reduction occurs at the negative electrode.

Question 17

The correct answer is D. The mass number of 4 and the atomic number of 2 means there are 2 neutrons and 2 protons in the Helium atom. The mass of the atom is slightly more than this due to the 2 electrons that are also present, which have an infinitely smaller mass than the protons or neutrons but still need to be considered.

Questions 18

The correct answer is A. When the cell is recharging, the reaction is reversed (it works like an electrolytic cell when recharging) and $Cd^{2=}(s)$ is reduced at the negative electrode (the cathode).

Question 19

The correct answer is B. When the cell is discharging, the product formed at the negative electrode (the anode) is $Cd^{2+}(s)$.

Questions 20

The correct answer is D. The product formed at the positive electrode (the anode) is NiO(OH) as the nickel is oxidised to the 3+ oxidation state.

Section B – Short-answer questions

Marks allocated are indicated by a number in square brackets, for example, [1] indicates that the line is worth one mark.

Question 1a

The specific heat of the car door metal is much lower than the specific heat of the water [1]. Thus, the car door heats up far more quickly and is hotter to touch [1].

Question 1b

Longer hydrocarbon chains are needed during summer, whereas the mixture should be predominantly shorter chains during winter [1]. This is because a more volatile mixture is needed in cooler temperatures to encourage combustion. [1]

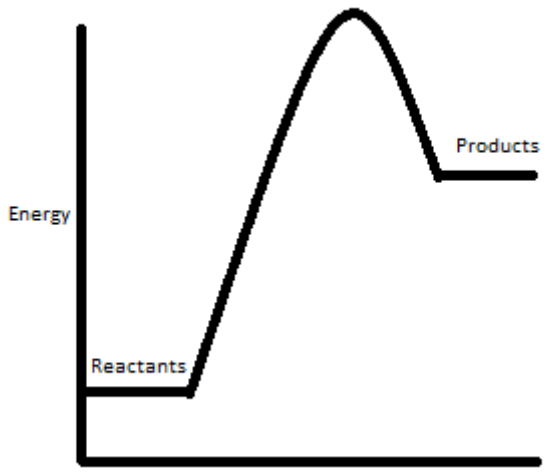
Question 1c

Using cryolite means that the melting temperature of the aluminium oxide is lowered from 2200°C to 980°C [1], .Thus, it lowers the energy costs of the reaction [1].

Total: 6 marks

Question 2a

The reaction is endothermic [1]. Even students with no biological knowledge should be able to answer this question as the addition of sunlight indicates that energy is required for the reaction to proceed. The energy profile should look like this [1]:



Question 2b

A catalyst lowers the activation energy of a reaction without being used up in the reaction itself [1]

Question 2c

469 – 128 = 341kJ/mol [1]

Total: 4 marks

Question 3

A choice of four industrial chemicals could be made. The sample answer is given for sulphuric acid. If you studied a different chemical and are unsure of your answer, check with your tutor or teacher.

Question 3a

Uses of sulphuric acid include, but are certainly not limited to: production of superphosphate fertiliser, as an oxidant, in lead acid batteries for cars, in crude oil refinement and in waste water management. [1] mark for any of these or any other reasonable suggestion.

Question 3b

$H_2S_2O_7(l) + H_2O(l) \rightarrow 2H_2SO_4(l)$ [1]

Question 3c

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ ΔH: negtive [1]

Question 3d

i. The reaction is exothermic [1], so increasing the temperature pushes the reaction to the left and favours the reactants to partially offset the temperature change [1]
ii. Increasing the pressure pushes the reaction to the left and favours the products [1] because there are fawer moles of products than reactants. Thus, favouring the products means that the decrease in pressure is partially offset [1].

Question 3e

[Any 2 of the 3 following conditions and explanations for 4 marks]

The reaction is carried out at 1atm pressure. [1] Although a higher pressure would be desirable for a higher yield, using large-scale high pressures is expensive, and as a 98% yield is achieved anyway, the costs outweigh the benefits and 1atm is used. [1]

The reaction is carried out at approximately 400 – 450^{o}C . [1] Although lower temperatures would produce a higher yield for this exothermic reaction, this temperature is used so that the reaction rate is not too slow. [1]

A catalyst, vanadium oxide V_2O_5, is used [1] to decrease the activation energy of the reaction and thus increase its rate. [1]

Question 3f

There are many potentially acceptable answers. An example of a correct response includes:

- Workers must wear face masks [1] because sulphur dioxide and sulphur trioxide are respiratory irritants [1]
- Tanks must be tightly sealed [1] because sulphur dioxide and sulphur trioxide can cause acid rain if allowed into the atmosphere

Total: 14 marks

Question 4a

If the vinegar has a pH of 3.65, $[H_3O^+] = 10^{-3.65} = 2.24 \times 10^{-4}$ M [1]

We know the K_a value and $[H_3O^+]$ so use the formula $K_a = \frac{[H_3O+]^2}{[\text{ethanoic acid}]}$

Computation reveals that the concentration of ethanoic acid is 0.00286M [1] (working must be shown to gain the mark)

Question 4b

Find the hydronium ion concentration of the solution using the formula:

$$K_a = \frac{[H_3O+]^2}{[\text{ethanoic acid}]}$$

$[H_3O^+]$=0.0027 M [1]

Find the pH of the solution: $-\log_{10}([H_3O^+]) = 2.59$ [1]

The pOH is 14 minus the pH, so pOH=11.41 [1]

Question 4c

The acidity constant of an acid is related to its willingness to donate an H^+ ion [1]. A triprotic acid has 3 hydrogen ions, so is more likely to donate one than a diprotic acid, which is more likely to donate one than a monoprotic acid [1].

Total: 7 marks

Question 5a

A calorimeter should be well insulated so that most of the energy produced in the reaction taking place inside of it can be converted into measurable heat energy [1]

Question 5b

A calorimeter should be calibrated so that any heat loss due to poor insulation is taken into account when measuring the heat of a reaction, thus allowing accurate results to be obtained [1].

Question 5c

Energy = VIt = 5.84 x 1.20 x 60 = 420.5J [1] (remember to convert minutes to seconds)

Calibration factor = 420.5/1.30 = 323.4 $J°C^{-1}$ [1]

Question 5d

Energy = 323.4 x 2.4 = 776.3J [1]

Heat of combustion = 776.3/3.00 = 258.8 J/g → 2.6 x 10^2 J/g **[1]**

Question 5e

Because these are compounds without a known molecular formula, [1] so finding the number of mol would be impossible and thus grams are used [1]

Total: 8 marks

Question 6a

A fuel cell is a galvanic cell where reactants are added continuously and products removed continuously [1]

The main drawbacks include (1 mark per point)

- Difficult to transport
- Heavy
- Expensive electrodes
- Expensive to maintain due to needing to continuously provide reactants and remove products

Question 6b

A primary cell is a galvanic cell that cannot be recharged. That is, once it reaches equilibrium, it goes flat. A secondary cell is a galvanic cell that can be recharged by electrolysis once it reaches equilibrium [1]

An example of a primary cell is the Alkaline cell (battery) [1] (multiple possible answers)

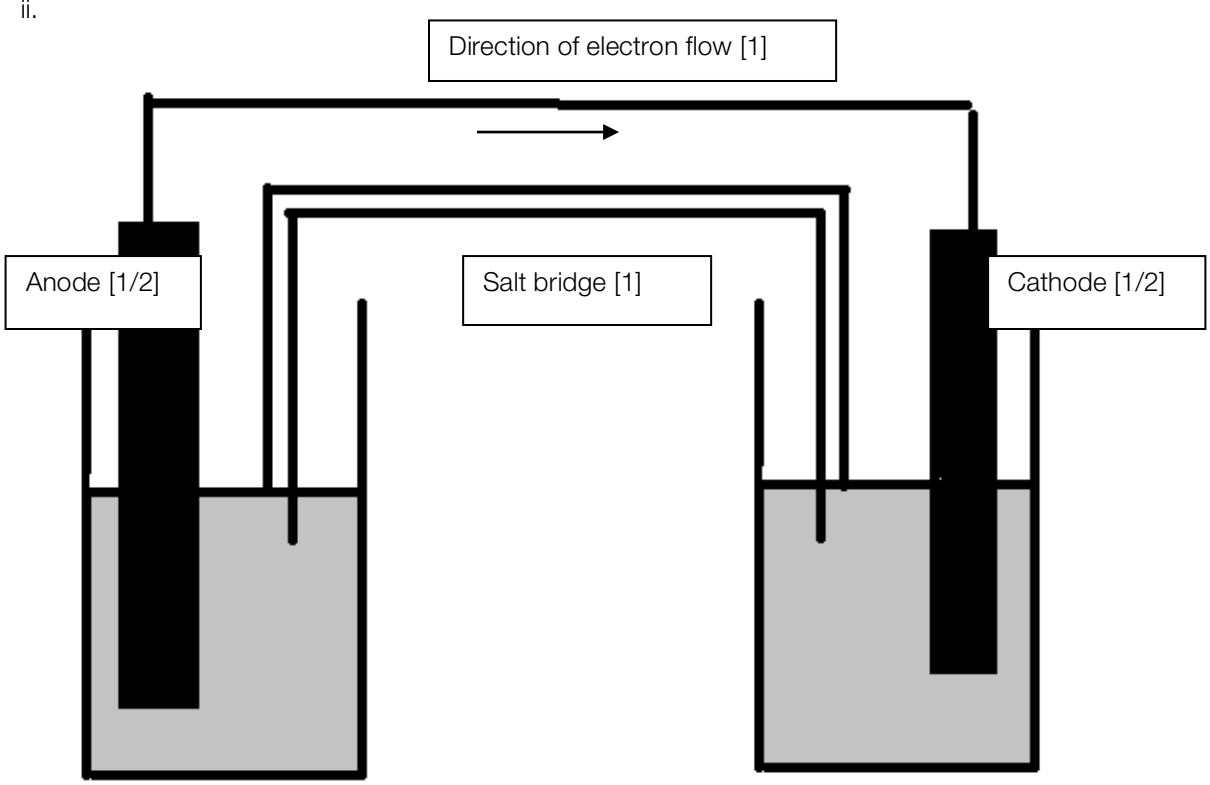
Question 6c

Graphite acts as an inert electrode as its sheet structure means that electrons can easily pass across it [1].

Question 6d

i. A suitable material for the anode would be iron metal [1] and a suitable reaction for the cathode would be graphite or platinum [1]

ii.



iii. The cell may not be operating at standard laboratory conditions [1]

Total: 12 marks

Question 7a

An electrolytic cell is the reversal of a galvanic cell and is used to obtain products that would otherwise be reactants due to their position in the electrochemical series. [1] They work by supplying electricity (electrons) to the cathode [1] at a potential higher than the cell potential [1] to force reduction to occur at the now negatively charged cathode and oxidation at the positively charged anode [1]

Question 7b

Cathode: $Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$ [1]
Anode: $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$ [1]

Question 7c

n(electrons) = 78000/96500 = 0.81 mol [1] (where Faraday's constant = 96500 C/mol)

n(product) = 0.81/2 = 0.404 mol [1]

m(Fe) = 0.404 x 55.8 = 22.551g → m(Fe) = 23 g (2 SFs) [1]

Total: 9 marks

End of solutions