Question 35 **(12 marks)**

Smoking is hazardous to a person's health and one option to help quit smoking is the use of nicotine patches. These patches, when placed on the skin, release small amounts of nicotine with the aim of reducing cigarette craving.

The nicotine content of these patches can be determined by titration. The titrating solution is prepared by mixing perchloric acid ($HC\ell O_4$) with glacial acetic acid, resulting in the following equilibrium:

$$HC\ell O_4 + CH_3COOH \rightleftharpoons CH_3COOH_2^+ + C\ell O_4^-$$

The species that reacts with nicotine during the titration is $CH_3COOH_2^+$. 'Glacial' means that the acetic acid does not contain any water.

The perchloric acid/acetic acid solution must be standardised before use and this can be done by titrating it with a solution made from a primary standard.

(a) Other than possessing a relatively high molar mass, state **two** characteristics required of a substance for it to be used as a primary standard. (2 marks)

One: _____

_____

Two: _____

_____

A brand of nicotine patches comes in dose sizes of 7 mg, 14 mg and 21 mg. A manufacturing error produced a batch of unlabelled boxes of patches. A chemist was given the task of identifying the dose size so that the boxes could be accurately labelled and then sold.

The chemist took one of the boxes and extracted all the nicotine from the 14 patches it contained. The nicotine extract was then made up to a total of 100.0 mL using a suitable solvent. Aliquots of the resulting solution (20.0 mL) were then titrated with standardised 0.0483 mol L^{-1} perchloric acid/acetic acid solution, requiring an average of 15.11 mL to reach the end point.

(b) Complete the following table by writing the name of the most suitable piece of equipment to use for each task. (3 marks)

Task	Piece of equipment to use
Making exactly 100.0 mL of nicotine-containing solution	
Measuring a 20.0 mL aliquot of the nicotine-containing solution	
Adding the perchloric acid/acetic acid solution to the nicotine-containing solution	

(c) Use the chemist's titration data to identify the nicotine dosage of the patches in the unlabelled boxes. Show all of your working.

The molecular formula of nicotine is $C_{10}H_{14}N_2$ and the titration reaction is:

$$C_{10}H_{14}N_2 + 2\ CH_3COOH_2^+ \rightarrow C_{10}H_{16}N_2^{2+} + 2\ CH_3COOH$$ (7 marks)