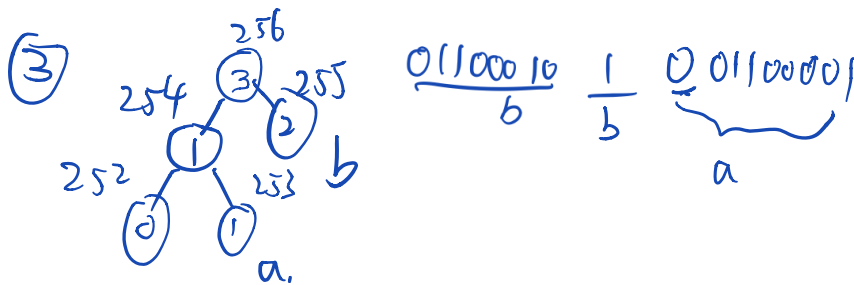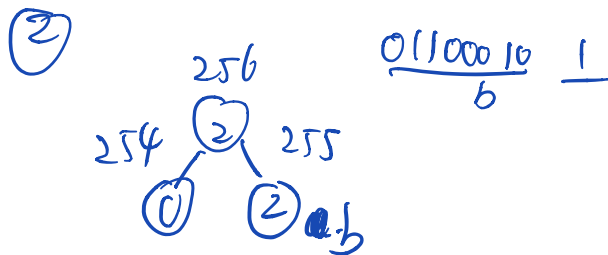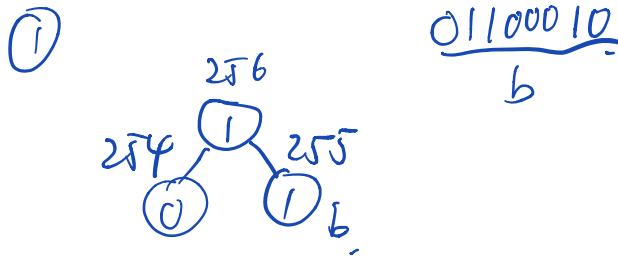**Question 4** (10 marks)

Adaptive Huffman Coding (Vitter's) is used to encode a string with a vocabulary of three letters a, b, c.

The initial coding before any transmission is: a=01100001, b=01100010, c=01100011.

Derive the encoded bitstream produced by the encoder for the string **bbaaacbbab**. Draw the final adaptive Huffman tree (the tree after the final letter is processed).

Instructions:

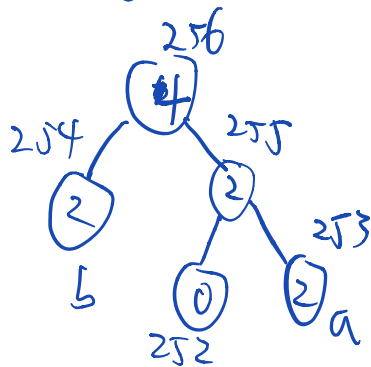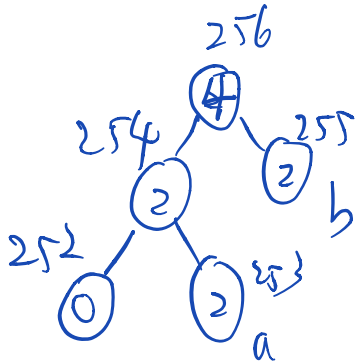- Save your answer and drawing in a file called q4.pdf in PDF format.

④ $\dfrac{0110001\,0}{b}\ \dfrac{1}{b}\ \overbrace{0\ 01100001}^{a}\ \dfrac{01}{a.}$

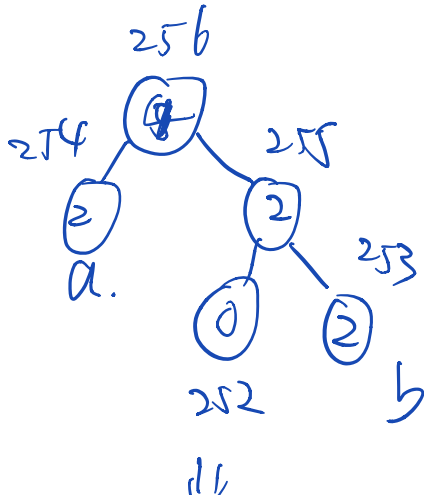256
(4)
254 (2) 255
(2)
252 (0) (2) 253
a
b

⬇

256
(4)
254 255
(2) (2)
b
(0) (2) 253
252 a

⑤ $\dfrac{0110001\,0}{b}\ \dfrac{1}{b}\ \overbrace{0\ 01100001}^{a}\ \dfrac{01}{a.}\ \dfrac{11}{a.}$

256
(4)
254 255
(2) (2)
a.
(0) (2) 253
252 b
11

256
254 255
3 2
a. 253
0 2
252

⟱ 256

256
254 255
5
2 3
254 a
253
0 2
252

(b) 0110001 0 | 1   0 0110000 1   01 | 11   00 0110001 1
         b   b   ̲a̲   a   a.   ̲c̲.

256
254 (6) 255
3 (3) a
252 253
(1) (2) b
(0) (1) 251
250 C

=>

256
254 (6) 255
(3) (3)
a 252 253
(1) (2) b.
251
(0) (1)
250 C

⑦

$$\frac{0110\,0010}{b} \quad \frac{1}{b} \quad \underbrace{0\,0110\,0001}_{a} \quad \frac{01}{a} \quad \frac{11}{a.} \quad \underbrace{00\,0110\,0011}_{c} \quad \frac{11}{b}$$
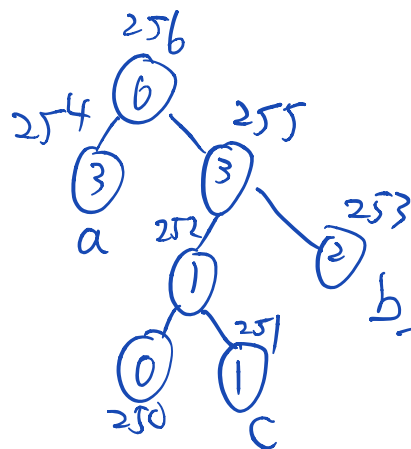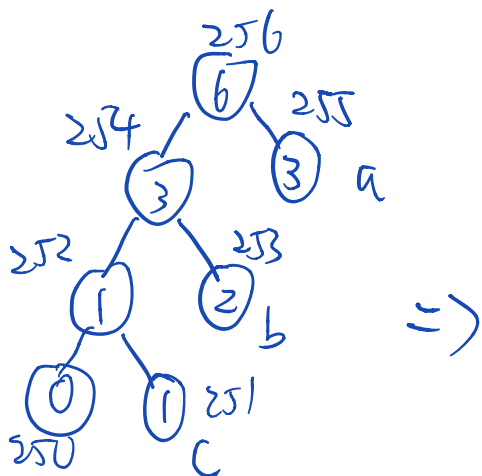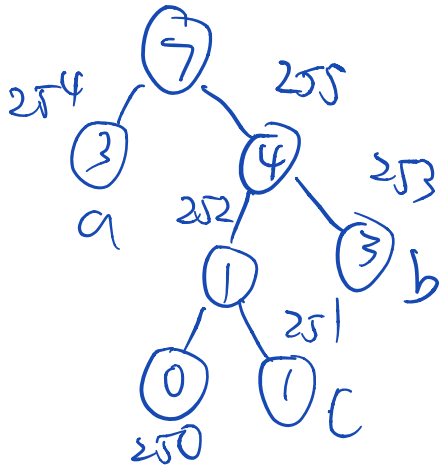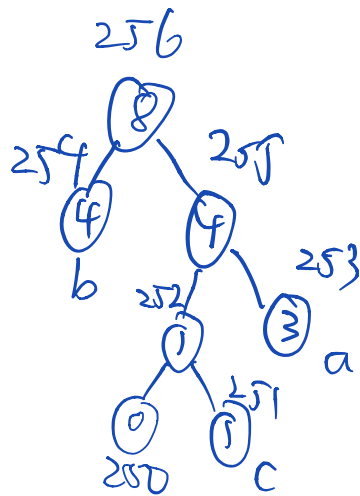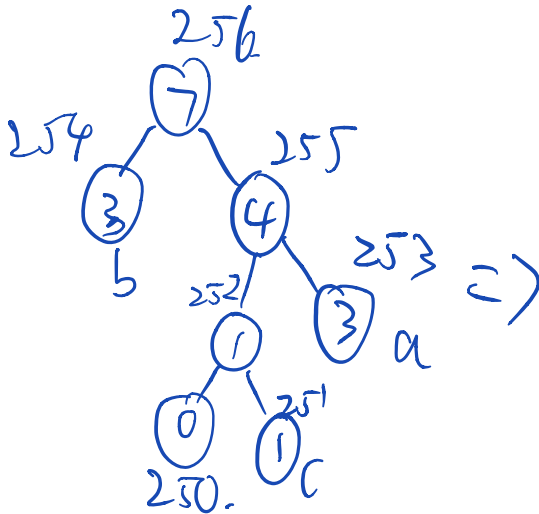
256

⑧

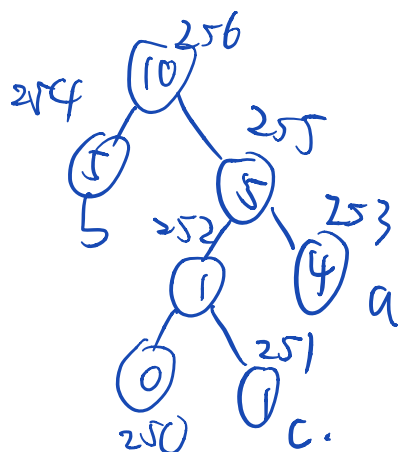$$\frac{0110\,0010}{b} \quad \frac{1}{b} \quad \underbrace{0\,0110\,0001}_{a} \quad \frac{01}{a} \quad \frac{11}{a.} \quad \underbrace{00\,0110\,0011}_{c} \quad \frac{11}{b} \quad \frac{11}{b}$$

256

=>

256

$\underset{b}{\underline{01100010}}$ $\underset{\underline{b}}{1}$ $\overset{0}{\underset{\underset{a}{\underbrace{\quad}}}{01100001}}$ $\underset{a}{01}$ $\underset{a.}{11}$ $\underset{\underset{c}{\underbrace{\quad}}}{00\;01100011}$ $\underset{b}{11}$ $\underset{b}{11}$ $\underset{a}{11}$

256

```
        (9)
   254 /    \ 255
    (4)     (5)
    b    252/  \ 253
        (1)    (4)
      / \        a
    (0) (1)
   250  251 c.
```

$\underset{b}{\underline{01100010}}$ $\underset{\underline{b}}{1}$ $\overset{0}{\underset{\underset{a}{\underbrace{\quad}}}{01100001}}$ $\underset{a}{01}$ $\underset{a.}{11}$ $\underset{\underset{c}{\underbrace{\quad}}}{00\;01100011}$ $\underset{b}{11}$ $\underset{b}{11}$ $\underset{a}{11}$ $\underset{b}{0}$

256

```
        (10)
   254 /    \ 255
    (5)     (5)
    5    252/  \ 253
        (1)    (4)
      / \        a
    (0) (1)
   250  251 c.
```

So final:

01100010 1 00110000 1 01 11 000110001 11 11 110