Question 1: (12 marks)

1) The PIC16F84 has
   a) 8-bit RAM and 14-bit ROM.
   b) 14-bit RAM and 8-bit ROM.
   c) 8-bit RAM and 8-bit ROM.
   d) 14-bit RAM and 14-bit ROM

2) A memory with 10 address lines and 32 bit word, has size of
   a) 320 Byte
   b) 32 Kbyte
   c) 1 MByte
   d) 4 Kbyte

3) If the nominal speed of a DC motor is 1,800 RPM, then in order to move the motor at a speed of 400 RPM, the duty cycle should be
   a) 22%
   b) 4.5%
   c) 45%
   d) 78%

4) Calculate the HEX value for COUNT to get a total of 1.5 msec delay in the subroutine below. Assume that the instruction cycle is 4 μsec

   Delay MOVWL COUNT
   MOVWF Timer
   Down DECFSZ Timer
   GOTO Down
   RETURN

   a) 7C
   b) 19
   c) 13
   d) 30

For the following two parts, refer to the SFR given next

<table>
<thead>
<tr>
<th>Bit 7</th>
<th>Bit 6</th>
<th>Bit 5</th>
<th>Bit 4</th>
<th>Bit 3</th>
<th>Bit 2</th>
<th>Bit 1</th>
<th>Bit 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTCON</td>
<td>GIE</td>
<td>EEIE</td>
<td>TOIE</td>
<td>INTE</td>
<td>RBIE</td>
<td>TOIF</td>
<td>INTF</td>
</tr>
</tbody>
</table>

5) To setup RB0 as an interrupt, the following should be stored in INTCON
   a) 01
   b) 10
   c) 90
   d) A0

6) In order to check if the RB0 interrupt had occurred, the microcontroller checks the bits
   a) TOIE
   b) INTE
   c) TOIF
   d) INTF
7) If TMR0 is loaded with 106 and the prescale is set to 64 and uses an oscillator of 10 Mhz. Then the delay time would be
   a) 3.84 ms   b) 0.68 ms   c) 2.71 ms   d) 0.94 ms

8) The author of the book *PIC Microcontrollers: an introduction to microelectronics* is
   a) Steven Gerard   c) William Haddadin
   b) Nicolas Sarkozy   d) Martin Bates

9) Specify the main differences between the PIC16F84 and PIC16F877 in terms of: digital I/O and timers.

10) Explain why power transistors are used to interface motors with μcontrollers

**Question 2: (10 marks)**

A temperature sensor is connected to A/D (AN5) in the PIC16F877.

- The sensor has a range: 0 to 51.2 C and a resolution of 10 mV/C.
- The A/D in the PIC16F877 uses Vref+ of 2.048V.

a) What is the **resolution** of the A/D in terms of V per bit?
b) What is the **resolution** of the A/D in terms of C per bit?
c) Specify the **word** to store in ADCON0 to setup the PIC to read from AN5.
d) Write **assembly instructions** to read the temperature and store it in GFR

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>ADCON0</td>
<td>ADCS0</td>
<td>ADCS1</td>
<td>CHS2</td>
<td>CHS1</td>
<td>CHS0</td>
<td>Go/DONE</td>
<td>--</td>
</tr>
<tr>
<td>ADCON1</td>
<td>ADFM</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>PCFG3</td>
<td>PCFG2</td>
<td>PCFG1</td>
</tr>
</tbody>
</table>
Consider the tank-mixing process below.

Two materials A and B are used to make a product.

The operation is as follows:

Step 1: Valve A opens and material flows in the tank until it reaches level switch A. Then it closes.

Step 2: Valve B opens and material flows in the tank until it reaches level switch B. Then it closes.

Step 3: The tank is mixed (using motor) for a specific time. Then, the motor stops.

Step 4: Output Valve is opened and the Product flows out.

Your task is to use PIC16F84 to control the process.

a) Specify all the I/O used (and their connections) in the PIC

b) Write the Assembly program (include comments)
Question 4: (14 marks)

Design a circuit using **PIC16F84** for position control.

The controller should run a motor (in forward direction) for number of revs as set by a binary (8-bit) switch input.

- Use TMR0 for counting the revs.
- Use a combination of opto-sensor and 1-slot disc for reading the pulses.

Also, if a Reset switch is activated, the motor should move backward to its home position (use limit switch).

1) Draw the complete **schematic circuit** used in your design.
2) Write the **c-program** and include your comments.
3) If the disc wheel has a radius of 4-cm and has 2-slots, what should the count value be to move the worktable 37-cm?