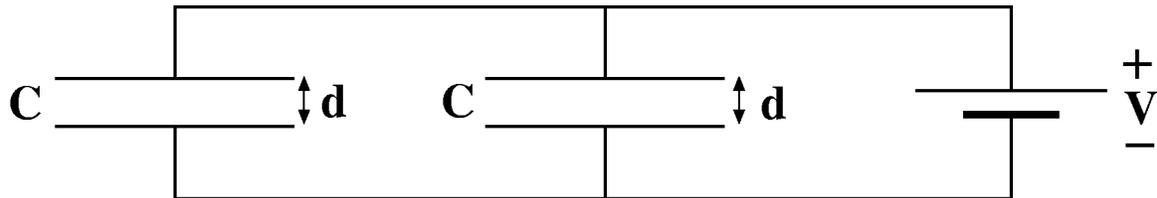


## Problem 2 (30 points)

Two identical ideal plate capacitors in air, each with capacitance  $C$ , are connected to a battery of voltage  $V$  as shown schematically below. The plates are separated by a distance  $d$ . Express all your answers in terms of  $C$ ,  $V$ , and  $d$  and also  $\kappa$  (in the case of questions c and d).



- (5) What is the total charge residing on **each** plate (4 answers please)?
- (5) What is the electric field (direction and magnitude) between the plates of each capacitor?

Without changing anything else (**the battery remains connected**), we fill the entire air gap of the capacitor on the left with a dielectric ( $\kappa = 3$ ).

- (10) What now is the total charge residing on **each** plate (4 answers please)?
- (10) What now is the electric field (direction and magnitude) between the plates of each capacitor?

## MIT 8.02 Spring 2002 Exam #1 Solutions

### Problem 1

~~(a) No bulbs glowing: no closed circuit anywhere and hence no current anywhere.~~

~~(b) A and B glow with equal brightness, as they are connected in series to the battery and thus the same current passes through each. C is still off.~~

~~(c) A, B, and C all glow. A is brightest, for all current flows through it. B and C glow with equal but lesser brightness, as the current through A is split equally between B and C.~~

~~(d) Bulb A in case (c) is brightest of all: effective resistance of the bulb combination is decreased from that of part (b) by the addition of bulb C in parallel with bulb B. By Ohm's law, more current is then drawn from the battery in case (c) as compared to case (b), leading to a brighter bulb A.~~

~~Bulbs B and C in case (c) are faintest of all. Let  $V$  be the battery voltage and  $R$  be the resistance of each bulb. The effective resistance of the circuit as a whole is  $2R$  in case (b) and  $1.5R$  in case (c). Thus the current through A is  $V/2R$  in case (b) and  $V/1.5R = 2V/3R$  in case (c). Therefore in case (b) the current through B is also  $V/2R$ , but in case (c) the current through B (and C) is *half* of  $2V/3R$ , which is  $V/3R$ . This latter current is less than  $V/2R$ , and so B and C in case (c) are fainter than A and B in case (b).~~

~~(e-b) B glowing, C off.~~

~~(e-e) B and C glowing with equal brightness.~~

~~(e-d) All on-bulb brightnesses are equal, for all bulbs have the full battery voltage across themselves, and therefore the same current goes through each.~~

### Problem 2

(a)  $Q = CV$ , and  $C$  &  $V$  are the same for both capacitors. So each has a charge  $+CV$  on its upper plate and  $-CV$  on its lower plate.

(b) For both capacitors, electric field has magnitude  $E = V/d$  and is directed downwards (from + charge to -).

(c) Right capacitor:  $C$  &  $V$  unchanged, so  $+CV$  on upper plate and  $-CV$  on lower plate still. Left capacitor:  $V$  unchanged, but  $C \rightarrow \kappa C = 3C$ , giving charges  $+3CV$  on upper plate and  $-3CV$  on lower.

(d) Same answer as part (b), for  $V$  and  $d$  remain unchanged.