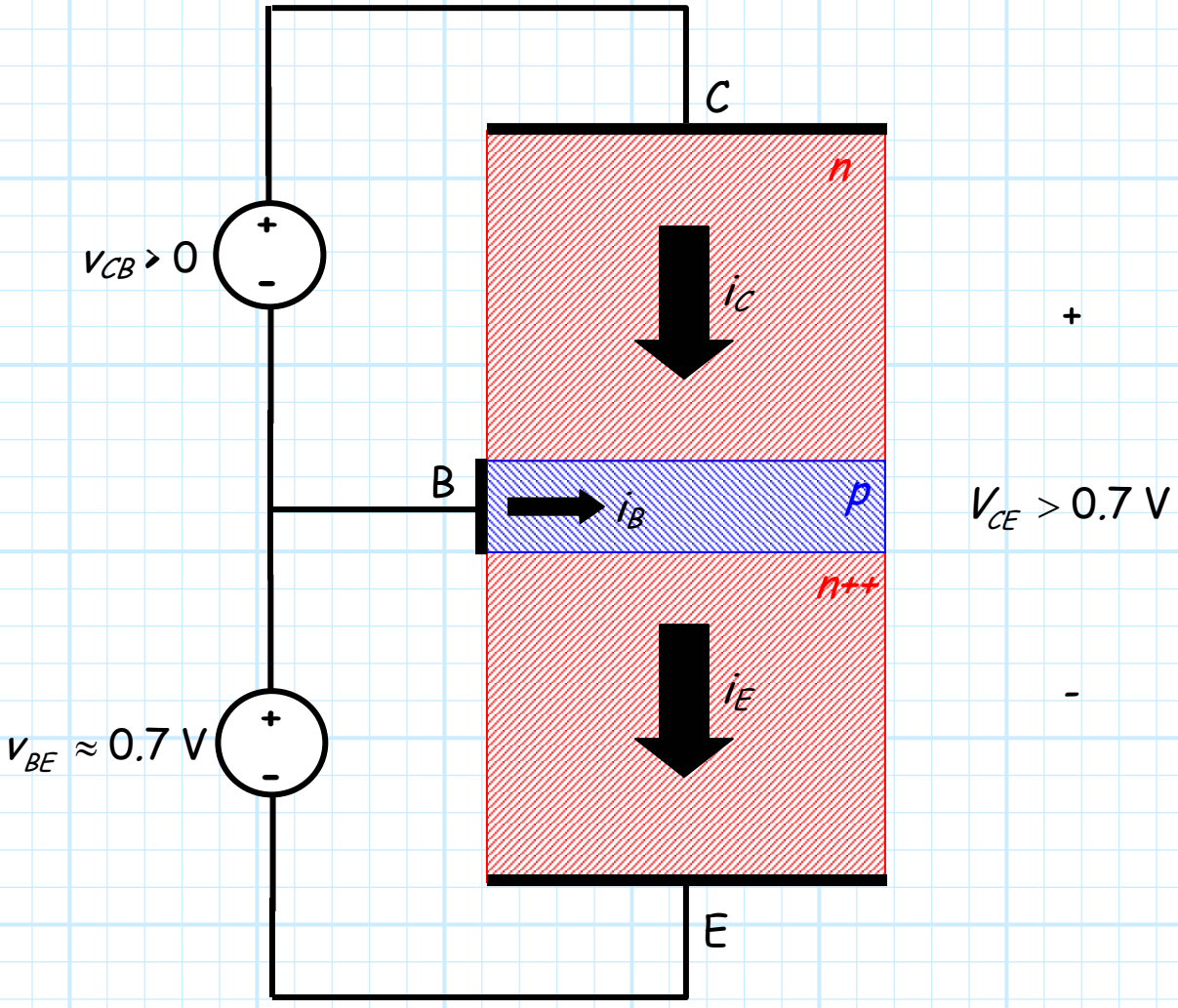
The *npn* Transistor in the Active Operating Region

We know that the **base-emitter** junction of an *npn* BJT in the **active** region will be **forward** biased, while the **collector-base** junction will be **reversed** biased. In other words:

$$v_B - v_E \doteq v_{BE} \approx 0.7\ V \quad \textit{and} \quad v_C - v_B \doteq v_{CB} > 0\ V$$



Q: *OK, if the collector-base junction is **reverse** biased, then **no** current will flow through the collector-base junction, meaning i_C **must be zero** and $i_B=i_E$, right ??*

A: **NO !** A BJT is more **complex** in its operation than that. Recall the base is **very thin**. This causes something **unusual** to happen!

* Recall that if the **collector-base** junction is reversed biased, then the barrier voltage is **large** and the **diffusion** current will drop to **zero**.

* However, recall also that the **drift** current is **unaffected** by the barrier voltage, so drift current **does** flow across the collector base junction !

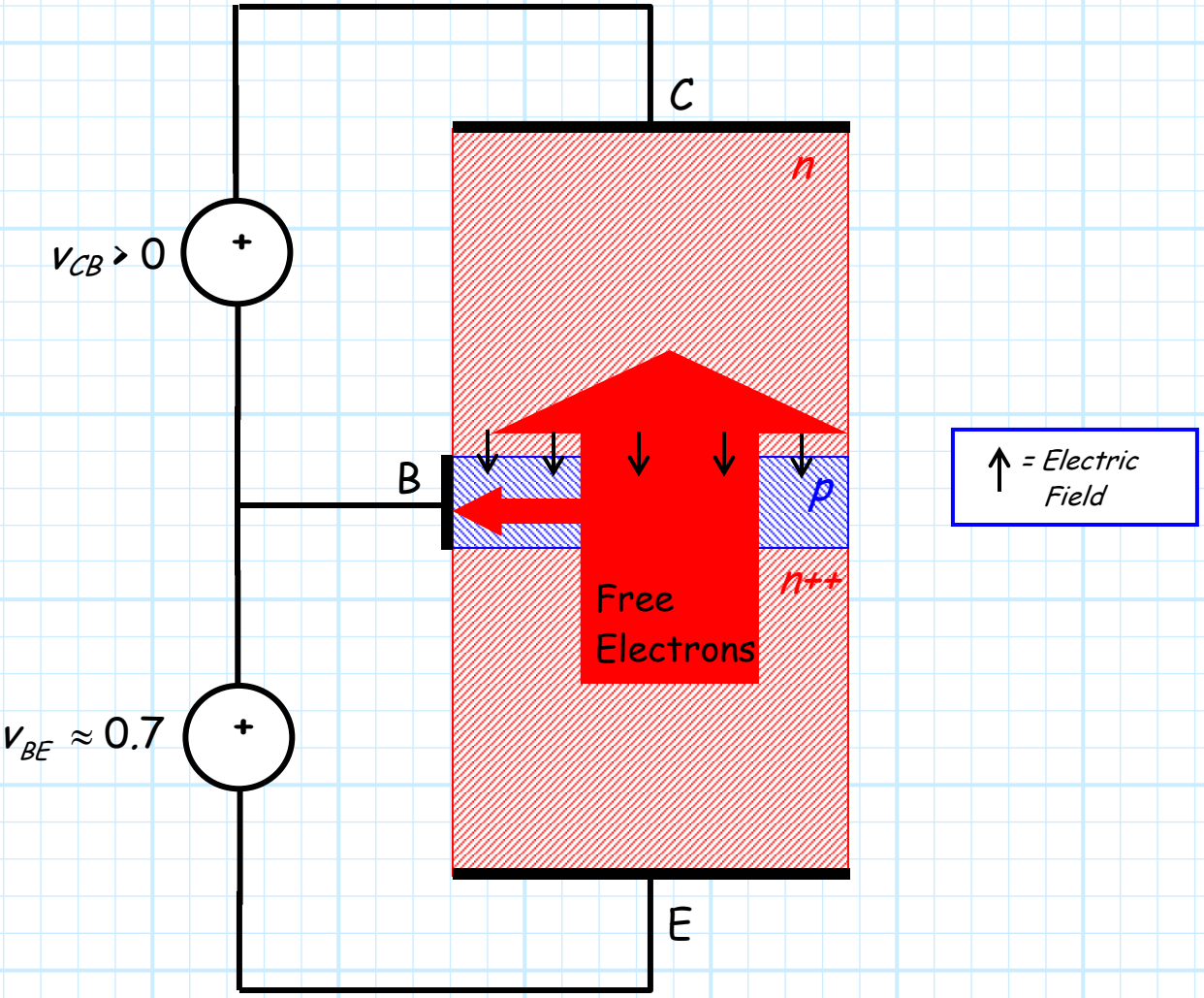
Q: *Pft! This diffusion current is really small, right? Like 10^{-12} A!?*

A: **NO!** Again, this is true for a junction diode, but **not** for a *npn* transistor.

* Recall that the **base-emitter** junction is forward biased, and therefore the **diffusion** current across this junction is **large**.

* The **emitter** region of an *npn* transistor is **heavily** doped (n++), so that the **diffusion** current primarily consists of **free electrons** moving from the emitter into the base.

* Normally, these free electrons would move to the **base electrode**, and some still do. But **most** get **swept across** the collector base junction by the **electric field** in the depletion region.



In other words, the large number free electrons in the emitter **diffuse** across the base-emitter junction into the base, then **drift** across the collector-base junction into the collector.

We say that emitter **emits** free electrons, and the collector **collects** them.

If the base is **thin**, then for every free electron that diffuses across the base-emitter junction, we find that **100 or more** are collected (i.e, drift across the CBJ) by the collector!